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THE BOTANICAL GAZETTE

Editor: JOHN M. COULTER

May 1913

Toxicity of Smoke — Lee I. Knight and Wm. Crocker

Western Plant Studies. I — Aven Nelson and J. Francis Macbride

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THE

BOTANICAL GAZETTE

MAY 1913

TOXICITY OF SMOKE

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY 171

LEE I. KNIGHT AND WM. CROCKER

I. Introduction

(WITH FOUR FIGURES)

Extensive unpublished experiments have been conducted in this laboratory to determine the reliability of the etiolated epicotyl of the sweet pea as a test for the presence of traces of heavy hydrocarbons in the atmosphere. As an outgrowth of this work, we have had occasion to study the response of this organ to smoke produced by the burning of various carbon-bearing substances, with the idea of discovering the constituent or constituents that produce the response.

The complete statement of the response of this seedling to gaseous impurities will involve two additional papers, one under the title "Is methane toxic?" and the other "The sweet pea epicotyl as a delicate test for heavy hydrocarbons." Both of these papers will be published shortly.

NELJUBOW (**25**) has shown that the etiolated epicotyl of the pea seedling has an abnormal growth in "laboratory" or "impure" air. We may speak of the abnormality as a triple response: change of negative geotropism to diageotropism, increased growth in thickness, and reduced rate of growth in length. We tested about 20 varieties each of garden peas and sweet peas, and found the sweet peas in

general considerably the more sensitive. Two varieties of these, under the trade names Earl Cromer and Gladys Unwin (Vaughan's Seed Store), were especially sensitive.

II. Methods

GROWING THE SEEDLINGS

Gladys Unwin and Earl Cromer are both hard-coated varieties. After 24 hours' soaking in water, about 10 per cent swell, and 10 days are required for all to swell. Consequently, in order to get uniform growth in the seedlings, the coats are scratched with a file and the seeds soaked for 15 hours in distilled water. They are then thoroughly shaken up with several changes of distilled water and placed in a thin layer between sterile wet filter papers and allowed to germinate. When the longest hypocotyls have reached a length of 5 mm., the seeds are transferred to wet sterile absorbent cotton in large petri dishes and allowed to grow in total darkness at 20°–24° C. until the epicotyls have an average height of 2–3 cm. This method gives cultures fungus-free and of far more nearly uniform growth than can be obtained by less careful methods. It also gives cultures bearing only the more vigorous seedlings. This is especially important, for sensitiveness to atmospheric impurities rises with the vigor of the seedlings. With all these precautions there is considerable irregularity in the rate of growth of the various epicotyls in a culture. The entire process must be carried on in what the German workers have called pure air, which means air practically free from the heavy hydrocarbons, especially ethylene. A quantity of this substance equaling one part in ten million of atmosphere interferes with the growth of the seedling.

In case the gas to be tested is very soluble in water, it is necessary to protect it against contact with the moist cotton bearing the roots. This is done by covering the substratum with low-melting paraffin mixed with pure paraffin oil. In many cases it was also found desirable to have a desiccating agent in the experimental chamber to keep its walls free from water given off by transpiration. This especially holds for gases like SO_2 and NH_3.

METHOD OF EXPOSING TO GASES AND VAPORS[1]

The exposure to gas or vapor was made in galvanized iron cans of the type shown in fig. 1, and of three capacities, 10, 50, and 100 liters. Each can consists of two pieces, the can proper and the bottom. The can proper has at *a* a side tube bearing a no. 3 two-holed rubber stopper. The stopper is equipped with glass tubes, rubber tubes, and screw clamps. The lower edge of the can has an out-turned brim, 1 cm. wide, at right angles to the sides of the can; this gives the can close continuous contact with the bottom. The bottom is a galvanized iron disk with 3 mm. of the edge turned up at right angles to the plane of the disk. The brim of the can fits closely inside the upturned margin of the bottom. To seal a culture in the can, it is placed on the bottom piece, the can set in position, and the gutter above the brim of the can carefully sealed with molding clay mixed with vaseline in such proportions as to give the desirable consistency. The seal will hold against a very considerable unequal pressure of gas. Vaseline was chosen as the mixing medium because it does not give off any fumes injurious to the seedlings and makes a material that maintains the same consistency after years of use. If the gas studied required the use of only a few cc., it was forced in through one of the tubes at *a* under a small head of mercury or water. Mercury was used in case the gas was very soluble in water, otherwise water was used. If a larger volume of the gas was required, suction was applied to one of the tubes at *a*,

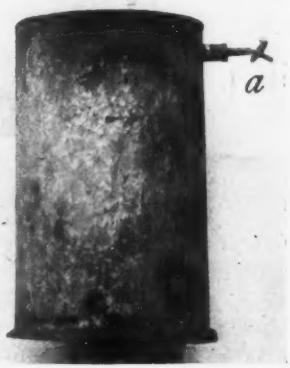

FIG. 1.—Apparatus for exposure to gases and vapors: explained in text.

[1] The description of methods here will cover the whole field of work, thereby avoiding redescription in later papers. For that reason many matters mentioned here do not apply to the work on smoke.

after which it was clamped. This suction served as the force for drawing in the gas through the second tube.

In cases where very large quantities of the gas were required, as with methane, the can was replaced by a bell jar and a water seal used. The whole apparatus was then placed in a dark chamber. To make sure of the reliability of the can, this method was also frequently used as a check in case of gases demanding only low concentration and not readily absorbed by water. If the vapor of a very volatile liquid, like ethyl ether, was to be used, a measured quantity of it was forced from a pipette into the upturned end of one of the glass tubes at *a*. A glass dish bearing absorbent cotton was attached just under the inner down-turned end of the glass tube. The liquid volatilized from the cotton and its vapor was distributed throughout the can. Applying the gases and vapors in this way, at the most distant point from the seedlings, insured that they would not at any time receive higher than the finally distributed concentration. In case the vapor of a slightly volatile liquid, like propyl alcohol, was to be applied, the desired amount was dropped on absorbent cotton and quickly sealed in the can with the cultures. In this case, of course, the clamps at *a* are screwed down or the hole provided with a solid cork.

The cultures are always subjected to the influence of the gas for three days, the same period used in our experiments with the carnation. At the close of an experiment the epicotyls in any culture of controls vary in height from 5 to 13 cm., while the cultures subjected to injurious concentrations of gases show less growth.

In this method of experimentation, as is seen, the epicotyls are not subjected to the same concentration during the entire three days, for the gas is applied only at the beginning of the experiment. The concentration must fall to a degree varying with the different gases, due to absorption by the plant and substratum, and to some extent due to a slow diffusion outward through the seal. If the gas is one that is readily absorbed by the plant, as SO_2, the method probably more nearly determines the lethal dose. In the case of the carbon-bearing gases (acetylene, ethylene, propylene, methane, and carbon monoxide), with the exception of acetylene, which is

rather soluble in water, the method certainly gives a very close approximation to the constant concentration necessary to give a response. The object of the work was to determine the nature of the response given by the several gases and vapors and to approximate the concentration necessary to produce it. For this purpose the method is adequate.

III. Historical

1. RESPONSE OF THE PEA EPICOTYL

a) Horizontal nutation

As has been stated, the epicotyl of the pea seedling grows prostrate or horizontal in "laboratory" air. NELJUBOW (**25**) has spoken of this response as a *horizontal nutation*, and mentions ethylene and acetylene, both constituents of illuminating gas, as especially effective in producing it. He has shown (**26**), also, that the response is not limited to the pea epicotyl, but appears in the etiolated epicotyls of *Ervum lens*, *Lathyrus odoratus*, *Vicia sativa*, and *Tropaeolum*. SINGER (**42**) has observed the same for the potato stem. NELJUBOW has shown that the response in the pea epicotyl in an atmosphere containing ethylene varies with the concentration of ethylene. Beginning with the higher concentrations and passing to the lower, he mentions the following grades of response: (1) no growth, death; (2) no elongation, a swollen knob; (3) elongation slow, swelling, diageotropism; (4) elongation faster, little swelling, diageotropism; (5) like (4) except obliquely placed; (6) erect, but growth reduced by half.

The horizontal nutation has been a subject of no little investigation. With mere mention we can pass over WIESNER'S (**43**) conception of undulating nutation induced by darkness, and RIMMER'S (**39**) autonomic nutation induced by dryness, for at that time there were not sufficient data available for a rational interpretation of the response. MOLISCH (**20**) and KÖRNICKE (**17**) concluded that impurities of laboratory air affect geotropic and heliotropic sensibility in opposite ways, weakening the former and strengthening the latter. MOLISCH (**21**, pp. 170, 171) has apparently abandoned the idea of increased heliotropic sensibility.

RICHTER (**32, 33, 34**) speaks of the impurities weakening negative geotropism and has continuously maintained that they increase heliotropic sensibility. GUTTENBURG (**13**) has spoken of the horizontal nutation as due to weakened negative geotropism and vigorously denied increased heliotropic sensibility. He attributes the conclusion of other workers on the latter point to inaccuracies in experimentation, especially the failure to use the clinostat, thereby eliminating the antagonistic action of gravity.

NELJUBOW (**26**) has maintained since 1901 that the response is induced diageotropism. The evidence set forth in his last paper seems conclusive, marked as it is by excellence of experimentation. He criticizes the other workers for using "laboratory" air in which the quantity of effective impurity must vary from hour to hour, and in which the amount of impurity cannot be measured at any time. He used mixtures of pure air with 1–3 ppm. of ethylene. To maintain constant concentration the mixture was renewed daily. In this atmosphere on a horizontal clinostat the etiolated pea epicotyls showed great reduction in rate of elongation, also swelling but not bending. When grown in the same atmosphere off the clinostat, they showed the same characters with the addition of horizontal nutation. If in such an atmosphere the epicotyls were raised or lowered out of the horizontal position, they again assumed it. NELJUBOW maintains that diageotropism is the only assumption that can explain this behavior. He emphasizes that there is no autonomic nutation determining the direction in which the epicotyl turns to assume the horizontal position, but that it is entirely determined by its position in relation to the pull of gravity. RICHTER (**34**), working with seedlings of *Vicia sativa*, *V. villosa*, and *Pisum sativum*, shows that such a statement can hold only for epicotyls more than 1 cm. tall. On a clinostat or in "impure" air which "weakens" negative geotropism, the young etiolated epicotyls turn "backward" (in the direction in which the closed side of the curved tip faces) and crowd themselves closely against the substratum. This is an autonomic nutation incapable of manifesting itself off the clinostat in pure air on account of the counteraction of negative geotropism. Judging from the work of both NELJUBOW and RICHTER, the horizontal nutation of the etiolated

epicotyl of the pea, if less than 1 cm. tall, is due to the joint action of autonomic nutation and diageotropism; but, if taller than 1 cm., it is due to diageotropism alone. It should be mentioned in this connection that NELJUBOW worked mainly with taller epicotyls, which probably accounts for the autonomic nutations escaping detection by his careful methods.

b) The swelling

The increased diameter or swelling of a plant organ in the presence of poisons is apparently a rather commonly observed phenomenon. COOK and TAUBENHAUS (**5**) observed that in proper concentration of tannin the mycelia of various fungi tend to become short, thick, and much septate. GROTTIAN (**12**) finds that anaesthetics, especially chloroform, produce a swelling in the root just back of the tip, with constrictions above and below. NĚMEC (**27**) finds that chloral, ether, benzine, benzene, and alcohol vapors have a similar effect.

The anatomical structures of the swollen zone, along with the physiological condition causing the peculiar structure, has been a subject of some comment. As RICHTER (**35**) has stated, the swollen region shows an abundant development of collenchyma, also numerous rifts more or less lined with cork. RICHTER (**36**) has related the swollen condition and the development of rifts to excessive osmotic pressure induced by the poisons. So far as his cited articles are concerned, there is no evidence that he has made any measurements of osmotic pressures. His conclusions are based on two lines of indirect evidence. First, many observers have found an increase in osmotically active substances in plants grown in an atmosphere bearing poisons. JOHANNSEN has shown that soluble sugars increase in plants in the presence of ether and other anaesthetics. PRIANISCHNIKOW (**29**) has shown that etiolated lupine seedlings grown in laboratory air have a much greater amount of asparagin than those grown in pure air. The following table (p. 344) gives the difference, in percentage, wet weight, of asparagin in 12-day seedlings in pure air and laboratory air.

GRAFE (**10**) has shown that soluble sugars accumulate in plant organs at the expense of starch in an atmosphere bearing formalde-

hyde. GRAFE and RICHTER (11) have lately demonstrated that an atmosphere bearing acetylene or carbon monoxide changes radically the course of metabolism in various plant organs. In seedlings of *Vicia villosa* and *V. sativa* and stems and tubers of the potato, carbon monoxide (0.038 to 0.29 volume per cent in air) causes an increase in the sugar and amino content. In fatty seeds (squash and mustard) there is a decrease in sugar and amino compounds and an increase in glycerine and fatty acids. Acetylene interferes with the synthesis of sugar from glycerine and condensation of glycerine and fatty acids to fats.

PURE AIR		LABORATORY AIR	
Cotyledon	Epicotyl	Cotyledon	Epicotyl
0.140	0.289	0.348	0.625

The second evidence that RICHTER offers for poisons causing increased osmotic pressures is the fact that they often produce proliferation of sublenticular tissue similar to the substomatal proliferations or intumescences caused by high humidity. Very often, also, the lenticular protrusions, as well as other tissues, show guttation in the presence of poisons, which RICHTER interprets as indicating high osmotic pressure. Measurements of osmotic pressure would certainly be more to the point in the case of pea seedlings, though they might give less ground for philosophy and even a reverse conclusion. Aside from known relations to osmotic pressure, and only indirectly bearing on the point under discussion, it is well known that poisons, especially atmospheric impurities, produce considerable alteration in the structure and form of plants. The late work of GATIN (**8, 9**) on the effect of tarred roads on vegetation furnishes excellent examples of this. He finds that the fumes of tar bring about the disappearance of endodermis, alteration in the size and number of layers of cells in the cortex and other regions of the stem, and the transformation of doubly compound leaves into singly compound ones. Of less fundamental importance, perhaps, is the disappearance of starch and the formation of cork on leaf organs and young stems. RICHTER (**37**) has lately

summarized the effects of poisons upon the development of plant structures. Under modifications due to increased cell pressure, he mentions inhibition of growth in length, favoring of growth in diameter, splitting of the tissues with formation of rifts, lenticular and intumescence formation, and maceration in the living body. Other modifications that he relates to the rise of turgor are collenchyma formation, thickening of the epidermis, vacuolization of the nucleus, and fusion of the nuclei.

These two lines of general evidence are very interesting in connection with the response of the pea seedling, but after all they leave essentially untouched the real solution of the physiology of the response. This becomes more evident when it is remembered that our work shows three distinct types of response of this seedling to atmospheric impurities: (1) that produced by ethylene, acetylene, propylene, illuminating gas, various sorts of smoke, and possibly methane, and characterized by decreased rate of elongation, swelling, and diageotropism; (2) that produced by ether, chloroform, benzol, toluol, thiophene, xylol, cumene, and other substances, and characterized by decreased rate of elongation and swelling but not diageotropism; (3) that produced by ethyl alcohol, propyl alcohol, pyridine, hydrogen sulphide, hydrogen chloride, and other substances, and characterized by decreased rate of elongation, but neither swelling nor diageotropism. A careful detailed study of osmotic pressure, permeability, and metabolic (enzymatic, acid, respiratory, etc.) behavior of the seedlings, in each group of poisons might throw much light on the internal intimate physiology of the three types of response. A detailed study in this line might also relate diageotropism more closely with physical and chemical characters of the organ. This organ furnishes especially desirable material for such a study because of the ease with which it is changed from a negative to a diageotropic organ.

2. EFFECT OF TOBACCO SMOKE

MOLISCH has shown that tobacco smoke is extremely toxic to many plants. In his first paper (**22**) he reports the effect of tobacco smoke on various seedlings and microorganisms, and in a second paper (**23**) the effect upon adult plants. A third paper (**24**)

brings together all the main conclusions of the work, and emphasizes the bearing of the findings upon the growth of plants in dwellings, laboratories, etc.

Seedlings (*Vicia sativa*, *Pisum sativum*, *Cucurbita Pepo*, *Phaseolus vulgaris*, and others) are very sensitive to tobacco smoke. In its presence *Vicia sativa* epicotyls show what we have termed the triple response, also they fail to develop anthocyanin, a feature RICHTER (**38**) has observed for many plants grown in laboratory air. MOLISCH states that one to three whiffs of cigar or cigarette smoke in a 4.3-liter container caused the triple response. Smoke of paper, straw, and wood has effects similar to tobacco smoke, while fumes of nicotine have little influence on the seedlings. Carbon monoxide, pyridine, and hydrogen sulphide, in considerable dilution in the atmosphere, produce effects similar to smoke. MOLISCH quotes PONTAG as showing that cigar and cigarette smoke bear considerable quantities of carbon monoxide. On the basis of these data, MOLISCH concludes that carbon monoxide is probably the constituent determining the toxic limit of tobacco smoke for seedlings. Acquaintance with the work of NELJUBOW (**25**), CROCKER and KNIGHT (**6**), and LEHMANN (**18**) should have led him to recognize the high toxicity of ethylene for epicotyls of seedlings and other plant organs, the rather low toxicity of carbon monoxide, and the universal presence of ethylene in tobacco smoke. This immediately suggests the probability of ethylene being the constituent determining the toxicity for seedlings. MOLISCH's "whiff" methods are poorly adapted for matching the amount of carbon monoxide in the applied smoke against the amount demanded to produce the response.

Many microorganisms are likewise remarkably sensitive to tobacco smoke. A whiff of tobacco smoke blown across a culture of *Pseudomonas lucifera* "puts it out" in 0.5–1 minute. It readily recovers its power to phosphoresce when returned to sea water. *Chromatium vinosum*, *Beggiatoa*, *Spirillum* sp., *Amoeba*, *Vorticella*, *Paramoecium*, *Didymium nigripes*, and *Gymnodimium fucorum* are very sensitive to tobacco smoke, while *Pinnularia* and *Phycomyces nitens* are rather resistant.

Adult vascular plants behave variously toward the impurity.

Tradescantia guianensis, *Selaginella Martensii*, *Tolmiaea Menziesii*, *Eupatorium adenophorum*, and various echeverias are not interfered with at all by low concentrations of smoke in the air, and only slightly inhibited in their growth by great concentrations. The mature plants that are sensitive to tobacco smoke manifest it in three ways: (1) by chemotactic movements of the leaves; the leaves of *Boehmeria utilis* and *Splitgerbera biloba* showed epinastic movements when in a glass chamber of 4.5–7 liters with 1–3 whiffs of cigar or cigarette smoke; in *Boehmeria* the movement continues beyond the vertical position, with the formation of spirals in the petiole; (2) by lenticular protuberances; the development of lenticular protuberances occurred in sprouts of the potato and stems of *Boehmeria polystachya* and *Goldfussia glomerata* in the presence of tobacco smoke; while in *Salix rubra* and *Sambucus nigra* such protuberances develop in moist air, the process is greatly hastened by tobacco smoke; guttation commonly occurs in this lenticular tissue, due, as MOLISCH assumes, to high osmotic pressure; (3) by fall of leaves; tobacco smoke causes leaf fall in many plants; this is especially true of leguminous forms; 24–48 hours of exposure to tobacco smoke causes almost complete loss of leaves in *Mimosa pudica*, *Caragana arborescens*, *Robinia pseudacacia*, *Halimodendron argenteum*, and others; paper and wood smoke were likewise very effective in producing leaf fall, and nicotine very weakly so. MOLISCH states that in the mature plants he was not able to determine the constituent of tobacco smoke that does the injury.

IV. Observation and experimentation

AN OBSERVATION

A mishap in the greenhouses of this laboratory has some of the virtues of a real experiment. An attempt to kill the insects by the common method of burning tobacco stems resulted in the acute poisoning of many of the plants. This application of a high concentration of smoke for a short time did not, of course, show responses in the nature of nasties, swellings, abscissions, and nulled tropisms, as observed by MOLISCH with the application of lower concentrations

for long periods. The injury in this case must be stated in terms of the region and extent of killing. The records were taken five days after the mishap.

The following showed no injury: BRYOPHYTES, *Marchantia polymorpha*, *Conocephalus conicus* (not under spray); PTERIDOPHYTES, *Cyrtomium falcatum*, *Azolla caroliniana*, *Salvinia natans;* SPERMATOPHYTES, cycads, when not actively growing (*Dioon edule*, *D. spinulosum*, *Zamia floridana*, *Macrozamia Miquelii*, *Encephalartos cycadifolia*, *E. Lehmanii*, *E. Altensteinii*, *E. horridus*, *E. caffer*, and *Ceratozamia mexicana*), *Hibiscus rosa-sinensis*, *Zebrina pendula*, *Begonia semperflorus* (flowers and foliage), *Pelargonium zonale*, *Ficus elastica*, *F. lyria*, *Sagittaria variabilis*, and *Lemna trisulca*.

The following forms showed evident injury: BRYOPHYTES, *Riccia* (in pots on benches, all killed), *Conocephalus conicus* (growing under spray, all killed); PTERIDOPHYTES, *Lygodium* sp. (leaves all killed at tips and margins and many halfway back), *Pteris longifolia cristata* (tips and margins of leaves killed, brown spots on leaves), *Nephrolepis bostoniensis* (slight injury), *Aspidium longifolium* and *A. nidus* (some of the plants killed to the ground), *Alsophila denticulata* (badly injured); SPERMATOPHYTES, *Impatiens Balsamina* (all the older leaves brown-spotted), tomato (leaves entirely killed in most cases, but only at the tip in some), *Persia gratissima* (older leaves all killed), *Stevia serrulata* (all but youngest leaves killed), *Vinca alba* (ends and margins of leaves slightly injured), *Coleus* spp. (all older leaves fallen, young plants showed less injury). It is of interest that *Conocephalus conicus* growing on the benches was not injured at all, while a vigorous culture that had been growing for a long period under a spray was completely killed. It is possible that good water supply caused the development of a loose, poorly protected structure. It is likewise possible that the great surface of the spray water kept it nearly saturated with the poison of the smoke. From the data given above, one can see that in general the better cutinized forms are more resistant. Some will be interested in comparing these injuries with those from illuminating gas observed in a greenhouse by WILCOX (**44**). There is evidence to indicate that both injuries are due to a common substance, as we will see later. In the case reported by WILCOX, the poisoning

was more acute, due to longer application and possibly to greater concentration of the toxic material.

EXPERIMENTS

We will publish only a type experiment under each head, but in every case the experiment has been repeated several times to make sure the type experiment tells the truth. As has already been stated, we used the etiolated epicotyl of the sweet pea as the plant organ for testing the toxicity of smoke and its constituents, for we learned from our earlier experiments its behavior toward a great number of gaseous impurities, including the main constituents of smoke. This renders the determination of the constituents fixing the toxicity of smoke a simpler matter. Since the responses of the seedling to certain smokes and the variation of response with concentration is similar to the behavior toward ethylene, it is well to have in mind NELJUBOW'S (**26**) statement of the six types of response, varying with the concentration of the ethylene. They will furnish the data for an interpretation of the experimental results given below. Beginning with the higher concentrations, the responses are: (1) no elongation, death; (2) no elongation, vertical position, a knoblike swelling; (3) considerable elongation, swelling, horizontal position of the growing swollen part; (4) elongation greater, little swelling, horizontal position of part grown in ethylene-containing atmosphere; (5) like (4) except obliquely placed; (6) erect, but elongation rate reduced by half. Our failure to get a strictly horizontal position in many cases where NELJUBOW obtained it may be due to the fact that he changed the gas every day, thus maintaining an essentially constant concentration, while we applied the gas once and allowed it to stand for three days. The gradual absorption of the gas by plant, substratum, etc., may dilute it so that the epicotyl partly recovers its upright position. For our purpose, however, one application of the gas is adequate.

Experiment I.—Effect of unwashed smoke

When the experiment was set up, the etiolated epicotyls (Gladys Unwin) were 2–3 cm. tall, slim and vertical. The duration of exposure was three days. The following data show the sorts and

concentrations of the smokes used, along with condition of the epicotyls at the close of the experiment:

1. Check (in duplicate) in 10-liter chamber; epicotyls 6–11 cm. tall, vertical and slim.

2. Lighted cigarette sealed in 10-liter chamber; epicotyls 2.5–3.5 cm. long; swelling 0.5–1 cm. long; shorter swelling vertical and longer ones declined as much as 90°.

3. Lighted pine splinter in 50-liter chamber; epicotyls 3–5 cm. long; swelling 1–2 cm.; declination 50°–90°.

4. Lighted piece of linen paper (not giving lignin test) in 10-liter chamber; epicotyls 3–3.5 cm. long; swelling knoblike; no declination.

5. A lighted sheet of ashless filter paper (6 cm. diameter) in 10-liter chamber; epicotyls 1–2 cm. long; swelling 1–2 cm.; declination 60°–90°.

6. Two lighted straws (12 cm. long) partly burned in 10-liter chamber; epicotyls 3–3.5 cm. long; swelling knoblike, to 1 cm. long; declination 0°–90°.

7. Three whiffs of cigarette smoke in 10-liter chamber; reaction almost identical with 6.

8. 0.13-gm. linen paper burned as open sheet in 10-liter chamber; epicotyls 3–5 cm. long; swelling 1.5–2.5 cm.; declination 60°–90°.

9. 0.06-gm. linen paper burned in 10-liter chamber; epicotyls 4–7 cm. long; no swelling; diameter everywhere greater than in checks; declination 0°–15°.

10. 0.09-gm. linen paper burned in 10-liter chamber; reaction about the same as 9.

11. 1.45-gm. linen paper burned in 100-liter chamber; epicotyls 2.5–3.5 cm. long; swelling 0.5–0.75 cm.; slight declination.

12. 1.45-gm. linen paper burned in 50-liter chamber; reaction about as 11.

13. 0.36-gm. linen paper in 100-liter chamber; epicotyls 4–6.5 cm. long; no swelling, but larger diameter than checks; declination 20°–40°.

From this experiment it is evident that the smoke from the cellulose and lignin compounds is rather toxic. In agreement with MOLISCH, it shows that the toxic effect of tobacco smoke is not due to substances peculiar to tobacco, but is as marked for the smoke of pure cellulose. The unwashed smoke from 0.13 gm. of cellulose in 10 liters gives a response lying between NELJUBOW'S responses 3 and 4.

Experiment II.—Effect of washed smoke

In preparing the smoke, the cigar or cigarette (tobacco or paper) was smoked by suction and the smoke washed through two special wash bottles, one containing 15 per cent H_2SO_4, the other 40 per cent NaOH. According to LEHMANN (**18**), the first removes all

NH_3, nicotine, tar, and solids, while of course the latter removes CO_2 and H_2S. There results a mixture of colorless gases which is stored over water. This method of storage is adequate, since the most toxic constituent of the smoke is very slightly soluble in water, as shown by the slight fall in toxicity when thus stored, also by evidence given later in the paper.

To obtain the cigarette smoke used in the following experiments, 7 Murad cigarettes, weighing 1.3 gm. each, were two-thirds consumed, with a yield of 10 liters of gas. Each liter of smoke, therefore, results from the smoking of 0.6 gm. of cigarette; 20 liters of cigar smoke were produced by 15 gm. of cigars; each liter of smoke required 0.75 gm. of cigar. The paper smoke was derived from a cigarette of bond paper not giving lignin tests; 4 liters of smoke were produced from 1.4 gm. of paper; each liter was derived from 0.35 gm. of paper. So far as we know, the tobacco and paper smoke thus washed will contain, in common, nitrogen of the air drawn through in smoking, more or less unused oxygen, certain dry distillation gases of the carbon compounds involved (methane, ethylene, acetylene, and carbon monoxide), and perhaps higher homologues of methane, ethylene, and acetylene. The tobacco smoke will contain in addition traces of pyridine and perhaps other compounds. In this experiment the epicotyls in each culture at the beginning of the exposure varied from 2 to 3 cm. in height. The seedlings were subjected to the smoke for three days in total darkness at 20° to 24° C. The following data give the various concentrations and varieties of smoke used, along with the condition of the epicotyls at the close of the experiment.

1. Check culture in 50-liter chamber; epicotyls 6–12 cm. tall, vertical and very slim.

2.[2] 25 cc. of cigar smoke (output of 0.0188 gm. of cigar) in 50-liter chamber; epicotyls 4–7 cm. tall; greatest declination 30°; no swelling; greater diameter than check.

3. 50 cc. cigar smoke (output of 0.0375 gm. of cigar) in 50-liter chamber; epicotyls 3.5–4.5 cm. long; swollen; declined portion 1.5–2.5 long, with a declination of 75°–90°.

[2] In all the work the smoke was measured under existing atmospheric pressure. No corrections for barometric pressure and temperature were deemed necessary, for a doubling of the concentration was required to give noticeable differences in response, hence the errors of this method were far beyond detection by the seedling.

4. 100 cc. cigar smoke (output of 0.075 gm. of cigar) in 50-liter chamber; epicotyls 3.5–4 cm. long, with swollen regions 0.75–1.5 cm. long; swollen zones varying from upright to horizontal; the shorter swollen upright zones indicate that there is no growth in length.

5. 130 cc. cigar smoke (output of 0.097 gm. of cigar) in 50-liter chamber; many epicotyls showed knoblike swellings; no growth in length and no declination; many others were dead.

6. 200 cc. cigar smoke (output of 0.15 gm. of cigar) in 50-liter chamber; epicotyls mostly dead; living ones vertical, with a knoblike swelling; no growth in length.

7. 330 cc. of cigar smoke (output of 0.25 gm. of cigar) in 100-liter chamber; condition of epicotyls between that of 5 and 6.

8. 40 cc. of cigarette smoke (output of 0.024 gm. of cigarette) in 10-liter chamber; epicotyls 3–4.5 cm. long; swollen zone 1–2 cm. long; declination of swollen portion 80°–90°.

9. 20 cc. of cigarette smoke (output of 0.012 gm. of cigarette) in 10-liter chamber; epicotyls 3–6 cm. long; swollen portion 2–3 cm. long; declination of swollen part 70°–90°.

10. 10 cc. cigarette smoke (output of 0.006 gm. of cigarette) in 10-liter chamber; epicotyls 4–9 cm. long; little declination; no swelling; diameter of epicotyls greater than that of checks.

11. 20 cc. paper smoke (output of 0.007 gm. of paper) in 10-liter chamber; epicotyls 3–4.5 cm. long; swelling 0.75–1.5 cm. long; swollen portion vertical to horizontal.

12. 10 cc. paper smoke (output of 0.0035 gm. of paper) in 10-liter chamber; epicotyls 4–5 cm. long; swelling 1–2.5 cm. long and declined 70°–90°.

Several things are evident from these experiments. The smoke of paper and tobacco cigarettes is still very toxic after thorough washing with 15 per cent H_2SO_4 and 40 per cent NaOH. Later data will show that the constituents thus washed out have a comparatively low magnitude of toxicity. It becomes probable then that the high toxicity of paper and tobacco smoke is determined by the dry distillation carbon-bearing gases. Figuring on the basis of 10-liter containers, 10 cc. of cigar smoke (output of 0.0075 gm.), 40 cc. of cigarette smoke (output of 0.024 gm.), and 10 cc. paper cigarette smoke (output of 0.0035 gm.) give the third response mentioned by NELJUBOW (reduced rate of elongation, swelling, and horizontal position of the swollen part).

On the basis of the amount of washed smoke necessary to give the response, the cigar and paper cigarette smokes are about equally effective, and the tobacco cigarette smoke about one-fourth as

effective; while on the basis of the dry weight necessary to produce the smoke, the paper is more than twice and the cigarette only about one-third as effective as the cigar. The toxicity of the several smokes undoubtedly depends in part on the oxygen supply during the smoking. This will determine to some degree the amount of dry distillation gases escaping oxidation, although much of these will escape oxidation under any condition, for the heat is sufficient beyond the ignited portion of the cigar or cigarette to cause dry distillation, and here no burning of the dry distillation gases can occur. When the same paper used in making the paper cigarettes was burned as an open sheet in the 10-liter container, it required 0.14–0.21 gm. to give NELJUBOW'S third response. When burned in this way, the paper smoke is approximately 0.02 as toxic for this seedling. Burning the open sheet insures a more complete oxidation of the dry distillation carbon-bearing gases, both because of better oxygen supply and because of surer contact with the flame. It should be stated that the paper cigarettes used, though rolled only to moderate tightness, were difficult to smoke in the machine. They required considerable more suction than the cigarette and probably had low oxygen supply, as later analyses will indicate.

Experiment III.—Effect of washed smoke and chemical analyses

Two paper cigarettes, one loosely rolled and the other tightly, were smoked and washed with 15 per cent H_2SO_4 and 40 per cent NaOH and stored separately. The analyses of this sort of smoke according to the methods described by HEMPEL (**14**) are as follows:

Loosely wrapped paper cigarette; 4.78 gm. of paper smoked, with a yield of 8384 cc. of washed smoke.

	A	B
Volume of smoke taken for analysis	99.6 cc.	99.9 cc.
Volume after absorption with 40 per cent NaOH	99.6	99.9
Volume after absorption with bromine	99.5	99.9
Volume after absorption with phosphorus	99.5	99.9
Volume after absorption with ammoniacal cuprous chloride	84.4	85.0
Volume of CO	15.1	14.9

This analysis gives a trace of heavy hydrocarbons (bromine-absorbed gases) and approximately 15 per cent of carbon monoxide. The figures show that each gram of paper produced 263 cc. of CO. This yield is very high when compared with the yield from tobacco in cigarettes, cigars, and pipe as reported by LEHMANN (**18**). In these it varies from 15 to 101 cc. of CO per gram of tobacco. Our figures may be a little high, due to incomplete drying of the stub before weighing.

Tightly wrapped paper cigarette. In this case 3.41 gm. of paper produced 7357 cc. of washed smoke.

Analysis	A	B
Volume of smoke taken for analysis	97.6 cc.	92.4 cc.
Volume after absorption with 40 per cent NaOH.	95.8	90.6
Volume after absorption with phosphorus	95.8	90.6
Volume after absorption with bromine water	95.8	90.6
Volume after absorption with ammoniacal cuprous chloride	81.1	77.0
Volume of CO	14.7	13.6

In this analysis considerable CO_2 appears. On the basis of the CO_2-free smoke the CO constitutes 15+ per cent, approximately the same percentage shown in the analysis of the loosely rolled cigarette. There is not a measurable amount of heavy hydrocarbons, but in an analysis like this, where no corrections are made for temperature changes, it is possible to leave undetected 0.2 cc. In this case each gram of paper produced 327 cc. of CO, an even higher yield than given by the loosely rolled cigarette. This too is probably a little high, due to insufficient drying before weighing the stub back.

Effect on the seedlings.—At the beginning of the experiment the epicotyls were 2–3 cm. tall. The cultures were sealed in 10-liter cans and subjected to the smoke for 3 days. The following data show the nature and concentration of the smoke used, along with the condition of the seedlings at the close of the experiment.

1. Check; epicotyls 5–13 cm. tall, vertical and slim.

Washed smoke from loosely rolled paper cigarette

2. 10 cc.; epicotyls 3.5–5 cm. long; swollen portion 1–2 cm. long, with declination of 75°–90°.

3. 20 cc.; epicotyls 3–4.5 cm. long; swollen portion 1–1.5 cm. long, with declination of 75°–90°.

4. 50 cc.; epicotyls 3–4 cm. long; swollen portion 0.5–0.75 cm. long, with little or no declination.

Washed smoke from tightly rolled paper cigarette

5. 10 cc.; epicotyls 3–4.5 cm. long; swollen portion 1–1.5 cm. long, with declination of 70°–90°.

6. 20 cc.; epicotyls 3–4.5 cm. long; swollen portion 0.75–1.5 cm. long, with declination of 75°–90°.

7. 50 cc.; epicotyls 3–4 cm. long; swollen portion 0.5–0.75 cm. long, with little or no declination.

It appears from these experiments that the tightly rolled cigarette gives slightly the more toxic smoke, though not markedly

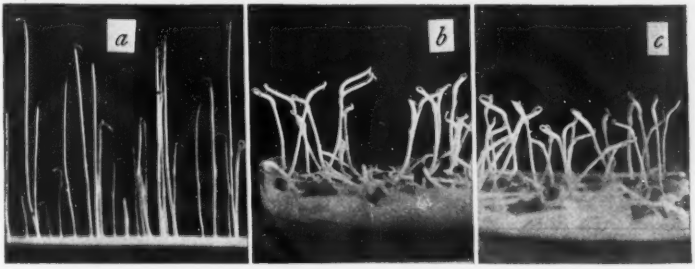

FIG. 2.—Responses to paper smoke: *a*, check; *b*, response to 10 cc. of smoke from loosely rolled paper cigarette in 10-liter chamber; *c*, response to 20 cc. of smoke.

so. In both sorts of smoke 10–20 cc. in 10 liters gives NELJUBOW'S third response, while 50 cc. in 10 liters gives his second response. It is apparent that considerable variation in concentration is necessary before a noticeable difference in response is shown. Even doubling the concentration may modify the response only slightly. This condition holds for ethylene, carbon monoxide, and a number of other gases, as our later paper will show. On the other hand, with pyridine, ethyl and propyl alcohol, acetylene, and others, rather slight variation in concentration is evidenced by very noticeable differences in the response. A series of photographs will give a more vivid idea of the response to smoke. Figs. 2 and 3 show the response to various concentrations of paper smoke.

Experiment IV.—Effect of bromine absorption on the toxicity of paper smoke

In this experiment the washed smoke from the loosely rolled paper cigarette was absorbed with bromine by the gas analysis method described by HEMPEL. All traces of bromine were later absorbed by washing with 40 per cent NaOH. As is well known, bromine absorbs the heavy hydrocarbons (acetylene, ethylene, etc., with their higher homologues). It does not absorb methane or carbon monoxide. If the substance determining the toxicity of this smoke is one of the heavy hydrocarbons, this treatment should reduce the toxicity. If it is carbon monoxide or methane, it should not greatly modify the toxicity. The cultures were sealed in 10-liter chambers and subjected to the various sorts and concentrations of smoke for three days. The data show the condition of the epicotyls at the close of the experiment.

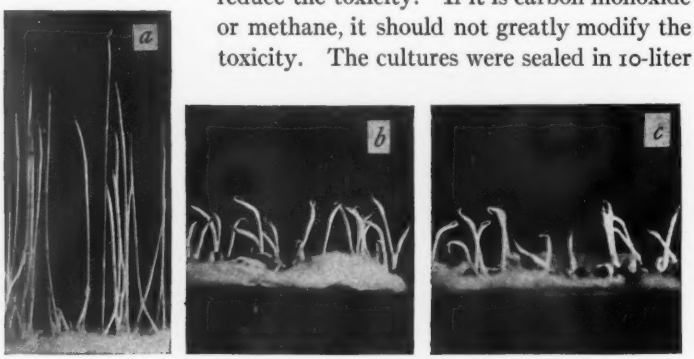

FIG. 3.—Responses to paper smoke: *a*, check; *b*, response to 20 cc. of smoke from tightly rolled paper cigarette in 10-liter chamber; *c*, response to 50 cc. of smoke.

1. Check; epicotyls 5–11 cm. tall, vertical and slim.

2. 20 cc. washed smoke not absorbed with bromine; epicotyls 3–4.5 cm. long; swollen portion 1–1.5 cm. long, with declination of 75°–90°.

3. 25 cc. (duplicates) washed smoke absorbed with bromine; epicotyls 6–12 cm. tall, vertical and slim.

4. 85 cc. washed smoke absorbed with bromine; epicotyls 4–9 cm. tall, vertical and slim.

5. 69 cc. washed smoke absorbed with bromine; epicotyls 4–9 cm. tall, slim and straight.

6. 92 cc. washed smoke absorbed with bromine; epicotyls 3–7 cm. long; no swelling and little declination.

7. 550 cc. washed smoke absorbed with bromine; epicotyls 3–5 cm. long; swelling 2–3 cm.; declination 10°–60°.

It is evident from this series of cultures that absorption with bromine greatly reduces the toxicity of paper smoke and shows that substances belonging to the heavy hydrocarbons are the ones determining the toxic limit. The response given with 550 cc. of bromine-washed smoke is probably due to the CO, for that amount of smoke contains about 82 cc. of CO.

Experiment V.—The effect of coal smoke

The smoke was withdrawn from the furnace of a large flat building on a cold day, when large volumes of soot-free air were pouring from the chimney. The smoke showed the following analysis.

Volume analyzed	93.6 cc.	99.3 cc.
After NaOH	92.2	97.6
Difference = CO_2+SO_2	1.4	1.7
	92.2	97.6
After phosphorous	75.8	80.2
Difference = O_2	16.4	17.4
	75.8	80.2
After ammoniacal cuprous chloride	75.6	79.9
Difference = CO	0.2	0.3

This smoke contained about 1.6 per cent of CO_2 and SO_2 together; long storage over water had probably reduced somewhat the percentage of these gases. The oxygen was reduced to a little less than 18 per cent, while only a trace of CO was present.

The following data report the results from exposing the test seedlings to various concentrations of this smoke. Part of these cultures were run in water-sealed bell jars and part of them in cans. At the beginning of the experiment the epicotyls were 2–3 cm. long, and after every exposure were slim and straight.

1. Control; epicotyls 6–12 cm. tall.

2. 20 cc. in 10-liter chamber; epicotyls 6–13 cm. tall.

3. 50 cc. in 10-liter chamber; epicotyls 6–13 cm. tall.
4. 500 cc. in 10-liter chamber; epicotyls 5–10 cm. tall.
5. One liter in 10-liter chamber; epicotyls 4–9 cm. tall.
6. Three liters in 6 liters; epicotyls 3–7 cm. tall.
7. Two liters in 6 liters; epicotyls 3–7 cm. tall.

It is evident that the chimney smoke is very slightly toxic. In one-half an atmosphere of this smoke the epicotyl is less inhibited in growth than in one part in 1000 of the smoke from the loosely rolled paper cigarette. This shows that the latter smoke is more than 500 times as toxic as the coal smoke used. In commercial furnaces it is customary to supply just enough air to oxidize completely all gases. Any considerable excess adds to the volume of heated air passing out of the chimney and to an economic loss from this source. It is in this that the flat-owner can be criticized rather than the point in question, the addition of poisonous carbon-bearing gases to the air, for his furnace was receiving about 10 times the volume of air necessary to give complete combustion. High oxygen supply probably accounts for the small amount of reduced carbon-bearing gases and for the low toxicity of the smoke. It is an open question in commercial furnaces, where there is little excess of oxygen, whether there is a sufficient amount of these gases to play any part in the injury of vegetation, as SEARLE (**41**) has suggested. In general, the injury from coal smoke has been attributed entirely to tars and the oxides of sulphur. It is certain, however, that carbon-bearing gases, especially ethylene, might be in sufficient concentration to do injury and still be in too small quantities for detection by chemical methods (**14**, p. 257). A full discussion of this point is given in the last section of this paper.

Effect of the various constituents of smoke

The experiments already recorded afford evidence that the heavy hydrocarbons determine the toxic limits of tobacco and paper smokes. It is desirable, however, to know the magnitude of toxicity of the several constituents, also the nature of the response produced in the epicotyl by each. Moreover, it is desirable to determine the particular hydrocarbon responsible. For paper smoke this will demand the study of ethylene, propylene, acetylene,

methane, and carbon monoxide, and in tobacco smoke pyridine, ammonia, hydrocyanic acid, and nicotine in addition, leaving entirely out of consideration the tars which have a relatively low toxicity where only their vapors are involved, and probably no such a magnitude of toxicity under any conditions as several of the carbon-bearing gases. Of these substances we will give detailed experiments only on carbon monoxide, hydrocyanic acid, and nicotine. For the other substances it will suffice merely to cite a portion of a table to appear in one of our later papers, along with the details from which it is derived. We consider the details on carbon monoxide here because it is the more abundant toxic gas and because MOLISCH suggests that it may be the one rendering the smoke so toxic to seedlings.

Experiment VI.—Effect of carbon monoxide

It is first desirable to make sure that the carbon monoxide used is free from the noxious gases, or at least that the effect produced is due to the contained CO and not to some impurity. For this reason the carbon monoxide was generated by three different methods and the three products compared as to their effects. It is assumed that if equal amounts of the three sorts of gas produce equal effects, the effect is due to the CO and not to impurities. Since the heavy hydrocarbons are so toxic, it was thought well to see whether washing the CO in bromine would reduce the toxicity.

When oxalic acid was heated with several times its weight of concentrated H_2SO_4 and washed with 40 per cent NaOH, a gas resulted which gave (duplicate analysis) 99 per cent absorption with ammoniacal cuprous chloride. Potassium ferrocyanide was heated with 8–10 times its weight of concentrated H_2SO_4 and washed with 40 per cent NaOH. In duplicate this showed 96 per cent CO. Sodium formate was heated with concentrated H_2SO_4 and produced a gas giving 89 per cent absorption with ammoniacal cuprous chloride.

The epicotyls were 2.5–3.5 cm. tall at the beginning of the experiment and were inclosed in 10-liter cans. The following data show the sources and concentrations (correcting for impurities) of CO used, and the condition of the seedlings at the close of the experiment.

1. Check; epicotyls 6–11.5 cm. tall, vertical and slim.

a) Potassium ferrocyanide-derived CO

2. 50 cc.; epicotyls 4–6.5 cm. long, with declination of 20°–45°; no swelling, but larger diameter than checks.

3. 100 cc.; epicotyls 3–5 cm. long; swelling 1–2 cm. long, with declination of 70°–90°.

4. 200 cc.; epicotyls 2.5–4.5 cm. long; swelling 1–1.5 cm. long, with declination 80°–90°.

5. 100 cc. washed in bromine; epicotyls 3–5.5 cm. long; swelling 1–2.5 cm. long; declination mostly 30°–60°.

6. 200 cc. washed in bromine; epicotyls 2.5–4 cm. long; swelling 1–2 cm. long; declination 60°–90°.

b) Oxalic acid-derived CO

7. 50 cc.; epicotyls 4–7.5 cm. tall; no swelling, but diameter larger than checks; declination 25°–35°.

8. 100 cc.; epicotyls 3–5.5 cm. long; swelling 1–2.5 cm. long; declination 60°–90°.

9. 200 cc.; epicotyls 3–5 cm. long; swollen zone 1–1.5, with declination 75°–90°.

c) Sodium formate-derived CO

10. 50 cc.; epicotyls 5–7 cm. long; no swelling, but declination 15°–40°.

11. 100 cc.; epicotyls 4.5–5.5 cm. long, with swelling 1.5–2.5 cm. long, and declination 60°–90°.

12. 200 cc.; epicotyls 3–5 cm. long; swollen zone 1–2 cm., with declination 70°–90°.

A series of photographs will show the response to CO (oxalic acid-derived) of various concentrations (fig. 4). It is evident that the responses obtained in this experiment are due to the CO contained in the gases and not to impurities. When the data and figures on CO are compared with those on smoke from paper cigarettes, it is seen that the smoke is about 10 times as toxic as pure CO; 10 cc. of the smoke give responses similar to 100 cc. of CO, and 20 cc. of the smoke similar to 200 of CO. Since the smoke is approximately 15 per cent CO, it contains only about $\frac{1}{60}$ enough CO to determine its toxicity. This helps to substantiate the conclusion that the heavy hydrocarbons determine the toxic limit of paper and tobacco smoke, so far as the plant organ studied is concerned.

Various amounts of nicotine (1–30 drops) were placed on filter papers and sealed in 10-liter cans with cultures. Only the smaller amounts completely volatilized, but in none was any inhibition of growth noticeable. The test seedlings in culture cans of various sizes, bearing several grams of pulverized KCN, showed no inhibition of growth. In this connection it should be stated that HCN exists in such small quantities in tobacco smoke (0–60 mg. from 100 gm. of tobacco) that LEHMANN (**18**) does not take it into consideration as a toxic factor with the smoker. It is certainly much less to be considered in plants to which it is rather slightly toxic.

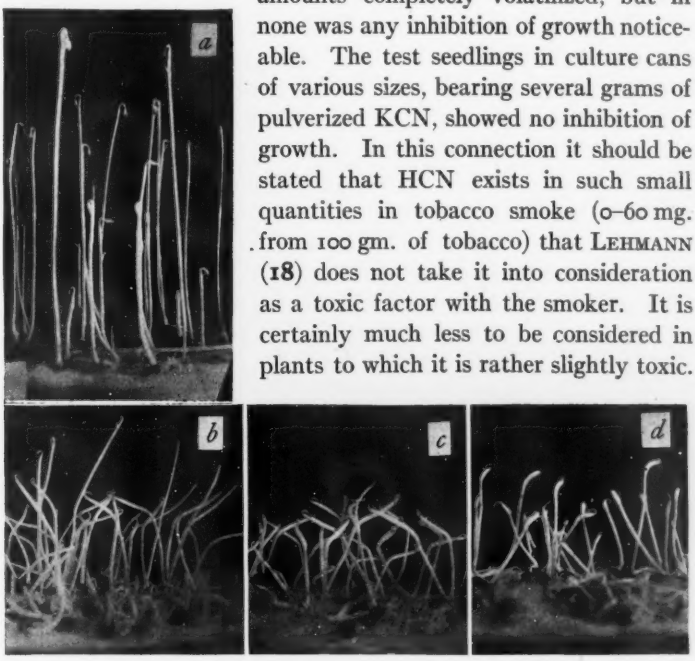

FIG. 4.—Responses to CO: *a*, check; *b*, 50 cc. of CO in 10 liters; *c*, 100 cc. of CO in 10 liters; *d*, 200 cc. of CO in 10 liters.

The following table (p. 362) shows the nature of the responses caused by other constituents of tobacco and paper smoke and the concentrations necessary to produce them.

In this table inhibition of growth corresponds to the sixth response of NELJUBOW, declination to the fifth, and horizontal nutation and swelling to the third. Only 4 of the 30 or more common gases and vapors whose effect on this organ we have studied certainly produce "declination" or "horizontal nutation and swelling." They are ethylene, acetylene, propylene, and carbon monoxide. This does not include the mixtures of gases (illuminating gas

and various smokes) in which the response is quite certainly due to one of these constituents. It also omits methane, for which it is not yet certain whether the response produced by the very high concentration given above is due to methane or to impurities. This uncertainty exists because methane derived by three different methods gave extremely great differences in magnitude of toxicity, though analyses showed the three sorts to contain approximately the same percentages of methane. At most, methane is very slightly toxic, if indeed further experiments do not prove it entirely harmless.

Gas used	Parts per million of atmosphere to produce		
	Inhibition of growth	Declination	Horizontal nutation and swelling
Ethylene	0.1	0.2	0.4
Acetylene	100.0	250.0	500.0
Propylene	75.0	1000.0	1000.0
Carbon monoxide	5000.0	5000.0	10,000.0
Methane	60,000.0?	200,000.0?	500,000.0?
Pyridine	300.0	None	None
Hydrogen sulphide	500.0	None	None
Ammonia	3000.0	None	None

The nature of the response (triple response) of the seedling to paper and tobacco smoke shows that it must be caused by one of the four carbon-bearing gases mentioned above or by homologues of some of them. Before going into the probability as to which of these determine the effective limit of the smoke, let us consider the concentrations of other constituents in unwashed tobacco smoke and the chances that they may play some part, at least, in the inhibition of growth, in experiments such as reported in this paper or those performed by Molisch.

According to Lehmann (**18**) 100 gm. of tobacco when smoked in a pipe or as a cigar produces about 16 cc. of H_2S. In experiment II (3) in which the smoke from 0.0375 gm. of cigar is placed in a 50-liter can, Neljubow's third response appears. The H_2S content in this experiment, if it had not been washed out, would be 1 part in 8 million of atmosphere, or about 0.0002 sufficient to reduce growth. According to the same worker, 100 gm. of tobacco when thus smoked produces 0.935 mg. of NH_3. In experiment II

(3), according to these figures, if the smoke had not been washed, ammonia would have been present in the proportion of 10 parts per million of atmosphere, or in about 0.003 sufficient concentration to inhibit growth. Pyridine exists in very small quantities in tobacco smoke, certainly far below amounts that would inhibit growth in experiment II (3).

Both the nature of the response of the seedling and the concentration of the smoke necessary to produce it indicate that one of the four carbon-bearing gases mentioned above or homologues of some of them fix its toxic limit. We have shown that it cannot be carbon monoxide on account of insufficient quantities of that substance. In what percentages of the smoke must the others exist to determine its toxicity? Let us consider experiment III (2) of washed smoke of the loosely rolled paper cigarette, almost as toxic as any tested. In this case it required 10 cc. of the smoke in 10 liters to give NELJUBOW'S third response, or the response listed in the table above as "horizontal nutation and swelling." Using the figures in the table above as the basis for calculation, ethylene must be present in 0.04 per cent, acetylene 50 per cent, and propylene 100 per cent of the smoke, to determine its toxicity. In experiment III (2) under discussion, the heavy hydrocarbons were not in sufficient concentration to be detected by the gas analysis methods used, which should easily detect 0.2 per cent. If one of these three gases is responsible, it must be the ethylene. In short, the sweet pea seedling will give the triple response in concentrations of ethylene 0.001–0.002 sufficient to be detected by gas analysis methods, while it will respond by reduced growth in concentrations 0.0003 to 0.0005 sufficient to be thus detected.

It is possible that in tobacco burned in the open, as is done when using it as an insecticide in greenhouses, the ammonia is produced in larger quantities as compared with the heavy hydrocarbons, and that ammonia much more nearly approaches the toxic limit. We have already shown that paper burned as a cigarette produces smoke 50 times as toxic as when burned as an open sheet. This means a great fall in the production of heavy hydrocarbons under conditions of high oxygen supply. There is probably also less ammonia produced when the aeration is better, for LEHMANN

(18) found that in cotton cigarettes impregnated with nitrates much of the nitrate nitrogen was reduced to ammonia nitrogen. Such reductions likely occur to a much slighter degree under better conditions of aeration. Similar conditions may hold for hydrogen sulphide.

V. General considerations

In the destructive distillation gases from carbon compounds, whether we consider smoke or illuminating gas, the preponderant toxicity of the heavy hydrocarbons, especially ethylene, is very interesting. The present paper shows this relation to hold for the sweet pea epicotyl, while a former paper pointed out the same situation for the carnation flower. Mr. E. M. HARVEY of this laboratory has shown that the ethylene in illuminating gas determines the toxic limit of that mixture to the roots of *Vicia Faba*, though in this case the magnitude of toxicity is much less than in the cases of the two plant organs mentioned above. In the light of the facts set forth in this paper, it becomes probable that the extreme toxicity of smoke for seedlings observed by MOLISCH (22) can be attributed to the heavy hydrocarbons. It is as yet unanswered whether the nocuous character of smoke to various microorganisms, and to the organs of mature angiosperms as observed by this writer, is due to the same constituent. Whatever be the case, it is clear that some plants are quite resistant to the destructive distillation gases of carbon compounds, as MOLISCH states and as RICHARDS and MACDOUGAL (31) have found. To what degree the resistance is due to protective structure or permeability characters and to what degree to peculiarities of the plasma cannot be stated.

It is probable that production of the toxic materials from carbon compounds begins considerably before the lower temperature limit set for destructive distillation is reached. In soils it was found in this laboratory that heating but slightly above 90° C. for an hour liberated substances that produced the "triple response" in the pea epicotyl. Mr. HARVEY is now making a study of the gases liberated from soils when heated at various temperatures. It is evident that contact of hot steam pipes with soil in greenhouses

may produce gases very toxic to plants. Whether they are likely to reach sufficient concentration to do injury is not determined.

Injuries from coal smoke are generally attributed to tars and oxides of sulphur (**3, 4, 7, 40,**), while reduced carbon-bearing gases have never been considered as a factor. According to HEMPEL (**14,** p. 257), these gases, especially the heavy hydrocarbons, exist in such small quantities, if at all, even when the oxygen supply is very little more than enough to produce complete oxidation, that they cannot be detected by gas analysis methods. This does not mean that they can be neglected as a source of injury to vegetation, for, as we have shown, growth rate is reduced in the pea epicotyl in 0.0003–0.0005, the least concentration of ethylene detectable by gas analysis methods. In short, while the gas analysis methods are quite adequate for guarding against considerable energy loss due to incomplete combustion of heavy hydrocarbons in furnaces, the only way to make sure that they are not in sufficient concentration to do injury to vegetation is to use a more delicate test, such as the pea epicotyl.

One factor that favors the effectiveness of the oxides of sulphur as plant poisons in the open as against heavy hydrocarbons is their great solubility in the plant cell, which would lead to their accumulation even under great variation in the atmospheric concentration, whereas the heavy hydrocarbons will accumulate to a far less degree, and variations in concentration greatly reduce their injurious effects. It is probable that smoke from the beehive coke oven is much richer in heavy hydrocarbons than furnace smoke, especially in the early firing (**2**). Part of the destruction of vegetation about these may be due to the carbon-bearing gases, though here, as in furnace smoke, there is an abundance of sulphur dioxide and tars. The economic loss through injury to vegetation is probably rather slight, because of the nature of the region in which this industry is carried on. It certainly is inconsiderable beside the $44,000,000 worth of products this wasteful method of coking is pouring into the atmosphere annually in the United States alone (**19**).

Artificial illuminating gas is a source of great economic loss through injury to plants. A large number of cases of injury to greenhouse stock in different parts of the country have been called

to our attention. As we have already pointed out (**6**), these losses generally occur during cold periods in winter. This insures a frozen crust, promoting lateral diffusion of the gas from the faulty mains; it also prevents ventilation of the greenhouses. So far as evidence for the constituents that produce the injury goes, it suggests the heavy hydrocarbons, though it is not by any means proved that these are responsible for all such injuries. A source of greater loss from illuminating gas is injury to shade trees. This injury is through the roots, in contrast to the injury in greenhouses. We are unable to state as yet what constituents produce the injury, though Mr. HARVEY'S work in this laboratory indicates that ethylene determines the toxic limit of the gas for the roots of *Vicia Faba*. Even so, it is possible that the less volatile materials of the gas accumulating in the soil may really be the source of injury, the power of accumulation overbalancing the higher toxicity. The determination of the constituents producing the injury and the tenacity with which they adhere to the soil are of great importance. They determine how soon and under what conditions replacing of the dead trees by new ones can be carried out. Mr. HARVEY is now attempting to answer these questions. The odor-producing substances of illuminating gas are retained in the soil with great tenacity, but so far as the pea epicotyl is concerned, these substances are innocuous, at least in concentrations easily detected by smell. Natural gases are generally low in heavy hydrocarbons; in fact, those of the Appalachian system bear none so far as chemical tests indicate (**1**); they consist mainly of methane and ethane. This gas should be very low in its toxicity to plants. The Baku natural gas is said (**30**) to contain some olefines.

The few facts established in this field suggest the need of rationalizing various practices in vogue and summarily abolishing others; for instance, the practice of burning tobacco stems in greenhouses for killing insects. This is a matter of differential poisoning, applying a poison that will kill the insect without injuring the plants. The processes volatilize nicotine and set free carbon monoxide, ethylene, and other gases. So far as we know, it is not certain which is the insecticide. If it is nicotine, why not volatilize nicotine from an extract and avoid the deadly plant poison ethylene?

If it is carbon monoxide, why not generate it chemically and thereby avoid ethylene? Again, it is a rather common practice to have the heating furnace in more or less open connection with the greenhouses. If one recognizes the probability of the dry distillation gases escaping from a furnace, along with the extreme toxicity of ethylene, he can see the need of abolishing this practice.

So far as known, the etiolated epicotyl of the sweet pea is the most sensitive plant organ to ethylene. As has been stated, it is inhibited in growth by 1 part in 10,000,000 of atmosphere. The open flower of the carnation is only a little less sensitive. In our original measurements (**6**), which were made on plants that had been bearing flowers for several months, 1 part in 2,000,000 of atmosphere "put the open flower to sleep" in 12 hours. Some later measurements with plants soon after they had begun to flower showed that 1 part in 3,000,000 of atmosphere caused the same response. While the open flowers on these younger plants were much more sensitive to ethylene, the buds proved much more resistant than the buds of plants longer in bearing.

If, in the few cases tested, two such sensitive plant organs have been found, it is probable that many more exist. So far as we know, there is in nature no special absorbent for ethylene, also no cycle for the gas, as there is for carbon dioxide and oxygen. Even if both existed, one doubts if 1 part in 10,000,000 would lead to a withdrawal. Processes of civilization are continually adding to the ethylene in the atmosphere, as burning of all carbohydrates, burning of coal (?), escaping of artificial illuminating gas, producing of gas in the beehive method of coking. escaping of certain sorts of natural gas, and probably other processes. Having no estimate of the total additions from these sources, one cannot calculate whether accumulation in the atmosphere up to a danger point is likely to occur.

The etiolated epicotyl of the sweet pea is a very delicate test for the heavy hydrocarbons, especially ethylene. One of the papers to be published later will show that under proper application it is also a very reliable test for this group of substances. It could be used to determine the presence or absence of this group of gases in coal smoke, gas from coal (**28**), and natural gas, where gas

analysis methods are inadequate. To the experimenter in plant physiology it furnishes an excellent means of making sure that the laboratory air is sufficiently "pure" not to interfere with plant response, while to the practical greenhouse man it furnishes a means of determining the probability of injury from illuminating gas or other mixtures bearing ethylene.

Summary

1. The smoke from tobacco cigars and cigarettes which has been thoroughly washed in 15 per cent H_2SO_4 and 40 per cent NaOH is very toxic to the etiolated epicotyl of the sweet pea. In the case of cigar smoke thus treated, 1000 parts per million of atmosphere give a triple response: reduction of rate of elongation, swelling, and diageotropism of the portion growing in the impurity; 5000 parts per million of atmosphere completely stop elongation and produce a swollen knob, while the epicotyl remains vertical; still higher concentrations kill the epicotyl before any form change occurs.

2. On the basis of dry weight burned, the washed smoke from cellulose paper cigarettes is even more toxic. The characters of the responses produced are identical with those produced by smoke from tobacco cigars and cigarettes.

3. When smoke from equal amounts of cellulose paper, smoked as a cigarette on one hand, and burned as an open sheet on the other, are compared, it is found that the former is 50 times as toxic as the latter. Higher oxygen supply during burning greatly reduces the toxicity. A large part of the toxic gases are undoubtedly oxidized to CO_2 and H_2O.

4. In the cigarette smoke of cellulose paper the following gases are present: carbon dioxide, carbon monoxide, acetylene, ethylene, methane, and some higher homologues of the last three. Washing out the carbon dioxide does not reduce the toxicity of the smoke, nor will carbon dioxide produce the type of response produced by the smoke. Carbon monoxide, acetylene, ethylene, propylene, and perhaps methane produce the same type of response as smoke. Carbon monoxide is in 0.015 sufficient concentration to determine the effect of smoke. It is not certain that methane is toxic at all;

if so, it is not in 0.00001 sufficient concentration to produce the response. The other three gases mentioned are not present in the smoke in sufficient quantities to be detected by ordinary gas analysis methods. Considering the magnitude of toxicity of acetylene and propylene, it is impossible that they play any part in the toxicity of paper smoke. The great toxicity of ethylene makes it probable that it determines the toxic limit. One part of ethylene in 10,000,000 of atmosphere inhibits elongation of the epicotyl, 4 parts in 10,000,000 produce the triple response. The toxicity of paper smoke is greatly reduced by washing with bromine, which is further evidence that ethylene or some other heavy hydrocarbon is the effective gas.

5. In addition to these gases, tobacco smoke bears hydrogen sulphide, ammonia, nicotine, hydrocyanic acid, and pyridine. None of these produces the type of response in the seedling caused by the smoke, and they exist in the smoke in concentrations far below that necessary to determine the toxic limit. The facts stated in this paper, along with the work of MOLISCH and others, show the hazard of using tobacco smoke as an insecticide for greenhouses.

6. The etiolated epicotyl of the sweet pea is a very delicate test for the heavy hydrocarbons (ethylene), exceeding many fold the delicacy of any chemical test.

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LITERATURE CITED

1. ALLEN, I. C., and BURRELL, G. A., Liquefied products from natural gas; their properties and uses. U.S. Bur. of Mines (technical paper) **10**:1–28. 1912.
2. BAUERMANN, HILARY, Coke in Encyclopaedia Britannica (11th ed.) **6**:655–657. 1910.
3. COHEN, J. B., and RUSTON, A. G., Smoke, a study of town air. pp. 1–88. Edward Arnold, London. 1912.
4. ———, The nature and extent of air pollution by smoke. Nature **81**:468–469. 1909.
5. COOK, M. T., and TAUBENHAUS, J. J., The relation of parasitic fungi to the contents of the cells of the host plant. I. The toxicity of tannin. Delaware Exp. Sta. Bull. **91**:1–77. 1911.
6. CROCKER, WM., and KNIGHT, L. I., Effect of illuminating gas and ethylene upon flowering carnations. BOT. GAZ. **46**:259–276. 1908.

7. CROWTHER, C., and RUSTON, A. G., Effect of atmospheric impurities near a large city. Journ. Agr. Sci. **4**:25–55. 1911.
8. GATIN, C. L., Die gegen die Abnutzung und den Staub der Strassen angewendeten Verfahren und ihre Wirkung auf die Vegetation. Zeitschr. Pflanzenkrank. **22**:193–204. 1912.
9. ———, Le goudronnage des routes et sou action sur la végétation avoisinante. Ann. Sci. Nat. Bot. **15**:165–252. 1912.
10. GRAFE, V., Untersuchungen über das Verhalten grüner Pflanzen zu gasformigen Formaldehyde. Ber. Deutsch. Bot. Gesells. **29**:19–26. 1911.
11. GRAFE, V., und RICHTER, O., Über den Einfluss der Narkotika auf die Anatomie und die chemische Zusammensetzung von Keimling. Anz. Kais. Akad. Wiss. (Wien) Math. Nat. Kl. **48**:536–538. 1911.
12. GROTTIAN, WALTER, Beiträge zur Kenntniss des Geotropismus über den Einfluss einiger anästhesierender Substanzen auf das Wachstum und den Geotropismus der Wurzeln. Beih. Bot. Centralbl. **24**:255–285. 1909.
13. GUTTENBERG, H. R. v., Über das Zusammenwirken von Geotropismus und Heliotropismus und die tropistische Empfindlichkeit in reiner und unreiner Luft. Jahrb. Wiss. Bot. **47**:462–492. 1910.
14. HEMPEL, WALTHER, Methods of gas analysis (translation from the third German edition by L. M. DENNIS). xix+490. New York: Macmillan. 1906.
15. KNIGHT, L. I., ROSE, R. C., and CROCKER, Wm., A new method of detecting traces of illuminating gas. Science N.S. **31**:636. 1910.
16. ———, Effect of various gases and vapors upon the etiolated seedling of the sweet pea. Science N.S. **31**:635–636. 1910.
17. KÖRNICKE, M., Weitere Untersuchungen über die Wirkung von Röntgen- und Radiumstrahlen auf die Pflanzen. Ber. Deutsch. Bot. Gesells. **23**: 324–333. 1905.
18. LEHMANN, K. B., Chemische und toxikologische Studien über Tabak, Tabakrauch, und das Tabakrauchen. Archiv. für Hygiene **68**:319–420. 1908–1909.
19. MOLDENKE, RICHARD, The coke industry of the United States as related to the foundry. U.S. Bur. of Mines Bull. **3**:1–32. 1900.
20. MOLISCH, H., Über Heliotropismus im Bacterienlichte. Sitzungsber. Kais. Akad. Wiss. (Wien) Math. Nat. Kl. **111**:141–148. 1902.
21. ———, Leuchtende Pflanzen. viii+1908 (citation pp. 170–171). Jena: Gustav Fischer. 1912.
22. ———, Über den Einfluss des Tabakrauches auf die Pflanze. Teil I. Sitzungber. Kais Akad. Wiss. (Wien) Math. Nat. Kl. **120**:3–30. 1911.
23. ———, Über den Einfluss des Tabakrauches auf die Pflanze. Teil II. *Op. cit.* **120**:813–838. 1911.
24. ———, Die Pflanze und Tabakrauch. Umschau **15**:259–264. 1911.
25. NELJUBOW, D., Über die horizontale Nutation der Stengel von *Pisum sativum* und einiger anderen Pflanzen. Beih. Bot. Centralbl. **10**:128–139. 1901.

26. ———, Geotropismus in der Laboratoriumsluft. Ber. Deutsch. Bot. Gesells. **29**:97–112. 1911.
27. NĚMEC, B., Über die Einwirkung des Chloralhydrates auf die Zell- und Kernteilung. Jahrb. Wiss. Bot. **39**:645–730. 1903.
28. PORTER, H. C., and OVITZ, F. K., The escape of gas from coal. U.S. Bur. of Mines (technical paper) **2**:1–14. 1911.
29. PRIANISCHNIKOW, D., Zur Frage der Asparaginbildung. Ber. Deutsch. Bot. Gesells. **22**:35–43. 1904.
30. REDWOOD, SIR BOVERTON, Natural gas in Encyclopaedia Britannica **19**: 274. 1910.
31. RICHARDS, H. M., and MACDOUGAL, D. T., The influence of carbon monoxide and other gases upon plants. Bull. Torr. Bot. Club **31**:57–66. 1904.
32. RICHTER, O., Pflanzenwachstum und Laboratoriumsluft. Ber. Deutsch. Bot. Gesells. **21**:180–194. 1903.
33. ———, Über den Einfluss verunreinigter Luft auf Heliotropismus und Geotropismus. Siztungsber. Kais. Akad. Wiss. (Wien) Math. Nat. Kl. **115**:265–352. 1906.
34. ———, Die horizontale Nutation. *Op. cit.* **119**:1052–1084. 1910.
35. ———, und GRAFE, V., Über den Einfluss der Narkotika auf die Anatomie und die chemische Zusammensetzung von Keimlingen. Verh. Gesells. Deutsch. Narutf. und Ärtze **80**:189. 1908.
36. RICHTER, O., Über Turgorsteigerung in der Atmosphäre von Narkotika. Lotos **56**:106–107. 1908.
37. ———, Neue Untersuchungen über Narkose im Pflanzenreiche. Mitt. Naturwiss. Ver. Univ. Wien **9**:14. 1911.
38. ———, Über Antocyanbildung in ihrer Abhängigkeit von äuseren Faktoren. Med. Klinik. **3**:1015–1020. 1907.
39. RIMMER, F., Über die Nutationen und Wachstumsrichtungen der Keimpflanzen. Sitzungsber. Kais. Akad. Wiss (Wien) Math. Nat. Kl. **89**:393–422. 1884.
40. RUSTON, A. C., and CROWTHER, C., Impurities in the atmosphere of towns and their effects upon vegetation. Report Brit. Ass. Adv. Sci. 577–578. 1910.
41. SEARLE, J. M., Coal smoke and its practical abatement. Report Engineer's Soc. Pittsburgh. pp. 18–19 (meeting of June 18, 1912).
42. SINGER, M., Über den Einfluss der Laboratoriumsluft auf das Wachstum der Kartoffelsprosse. Ber. Deutsch. Bot. Gesells. **21**:175–180. 1903.
43. WIESNER, J., Die undulierende Nutation der Internodien. Sitzungsber. Kais. Akad. Wiss. (Wien) Math. Nat. Kl. **77**:15–54. 1878.
44. WILCOX, E. M., Injurious effects of illuminating gas upon greenhouse plants. Ann. Report Neb. State Hort. Soc. pp. 278–285. 1911.

WESTERN PLANT STUDIES. I

AVEN NELSON AND J. FRANCIS MACBRIDE

[The last four numbers of "Contributions from the Rocky Mountain Herbarium" (IX–XII) were based largely upon the collections made by Mr. J. FRANCIS MACBRIDE in 1910 and by MACBRIDE and myself in 1911. During the season of 1912, the field work was continued by MACBRIDE assisted during a part of the time by Mr. DORMAN BENNITT and by the writer. The territory covered was a small part of southwestern Idaho and certain parts of Nevada in and adjacent to the Humboldt National Forest. Our work in Nevada was greatly facilitated by the kindly assistance of the Forest Service, and we wish to acknowledge gratefully the many courtesies extended by Supervisor C. SIDNEY TREMEWAN and his assistants and foresters. The types, the numbers of which are given, were all collected by NELSON and MACBRIDE and are deposited in the Rocky Mountain Herbarium.

In working up the collections of 1912, Mr. MACBRIDE has been associated with me, and the paper presented herewith is the result of this collaboration. This and other papers that we may publish jointly will be under the above title; while those for which I individually assume responsibility will be continued as "Contributions, etc."—AVEN NELSON.]

Calochortus bruneaunis, n. sp.—Stems striate, minutely scabrous in lines, especially near the base, 2–4 dm. high, more or less tortuous: bulb narrowly oblong, covered with brown, dead scales, as is also the base of the stem: leaves several (4–6); the radical leaf nearly or quite equaling the plant; the cauline involute, expanded and scarious-margined at the sheathing base, 4–10 cm. long: flowers 1–3, axillary in the upper leaves: sepals rather broadly lanceolate, 2–3 cm. long, tapering gradually to a slender tip, colored like the petals within, green without but with a broad white scarious margin to above the middle: petals broadly obovate-cuneate, rather abruptly rounded above into a blunt point, longer than the sepals; body-color white, delicately streaked with green, with a green band from apex to the narrow yellow claw, just above which is a small purple inverted **V**-shaped or lunate blotch: petal wholly glabrous, even the small oblong gland at the summit of the short claw scarcely pubescent: anthers obtuse, purple, 6–8 mm. long, about equaling the filaments: capsule narrowly oblong.

This makes the third species in the green-banded group, the others being *C. cyaneus* A. Nels. and *C. macrocarpus* Dougl. The latter is the nearer relative to the species now proposed. *C. bruneaunis* is easily distinguished by the rather tortuous stems, the different color and marking of the flowers, and the glabrous petal faces.

No. 1881, found in chipped lava, high on the canyon sides of the "Hot Hole" of the East Bruneau, Owyhee County, Idaho, is the type.

Clematis aurea, n. sp.—Glaucous, climbing freely by the petiolules: stems glabrous, striate: leaflets broadly to narrowly lanceolate, petiolate, pale green, irregularly incisely dentate, acuminate-cuspidate, midvein prominent beneath: bud green, drooping, erect in anthesis, the four sepals then golden yellow, 4–5 cm. long, oblong, obtuse, cuspidate, rather thick, prominently nerved, glabrous except for an incurved villous margin: the pubescent filaments dilated, 8–10 mm. long, all antheriferous; anthers linear, about 5 mm. long, obtuse, minutely cuspidate: achenes pubescent, the persistent black styles filiform, only moderately white plumose throughout, 4–5 cm. long.

Collected in July 1909, at Challis, Custer County, Idaho. It was locally plentiful, clambering over rosebushes, etc., along a stream, and attracted attention by its unusual color and beauty. It is a member of the section VIORNA, though with sepals scarcely leathery. In aspect the plant more nearly resembles some members of the section ATRAGENE.

Delphinium megacarpum, n. sp.—Much resembling *D. Andersonii* Gray, having a similar fascicle of long thickened woody roots and a strict mostly simple few-leaved stem: basal leaves petioled, from puberulent to nearly glabrous, suborbicular in outline, cuneately divided or parted, the lobes cleft into linear divisions; the stem-leaves rather remote, gradually reduced in size and number of lobes, puberulent or more usually sparsely hirsute-ciliate, the bracts and base of petioles conspicuously so: stems rather stout, 2–5 dm. high, at first cinereous-puberulent to the base, becoming glabrate below in age: inflorescence narrow, racemose and usually with one or more slender erect floriferous branchlets from the uppermost axils: flowers dark blue: calyx softly hirsute, spur longer than the sepals and these exceeding the petals: carpels puberulent even at maturity, linear-oblong, 20–25 mm. long, erect and parallel,

only the tips divaricate, reticulately veined: seed-body large, dark, narrowly winged on the margins and with a depressed summit.

This species has passed for *D. Andersonii* and is a close relative of it. The typical form of that seems to be confined to western Nevada and adjacent California. Taking those characters on which Dr. GRAY laid stress, namely, "very glabrous"; "follicles oval or oblong, not over half an inch in length"; "seed body small and broadly winged," as diagnostic, one is almost forced to separate this pubescent long-carpelled form. The segregate occurs in interior northern Nevada, Idaho, and adjacent Oregon. No. 1779, House Creek, Idaho, June 29, 1912, is the type number.

ARABIS MENZIESII **lata,** n. var.—Closely allied to the species, but the pods broader (as much as 6 mm.), 2.5–4.5 cm. long, usually about twice as long as the pedicels; style nearly wanting.

As shown in Proc. Biol. Soc. Wash. **17**:91 and **18**:187, the PHOENICAULIS section of *Parrya* is less aberrant in *Arabis* than in *Parrya*. Typical *Arabis* (*Parrya*) *Menziesii* will not run to *Parrya* by any of the keys to the cruciferous genera, but does run to *Arabis* by most, if not all, of such keys. The variety here described is probably the *P. Menziesii* of Bot. King Rep. 14, in part.

Fully mature material is our no. 1838, from lava cliff pockets, House Creek, Idaho, June 30, 1912.

ARABIS PEDICELLATA A. Nels., Proc. Biol. Soc. Wash. **17**:91 is *Parrya Menziesii lanuginosa* Wats., and may best become ARABIS MENZIESII **lanuginosa**.

Horkelia beneolens, n. sp.—Caudex simple or branched, more or less fleshy or becoming woody, thick because of the dense coat of dead brown petioles, the flaccid sordid herbage clammy with a short glandular pubescence: stems few–several from each crown, sparingly leafy, 7–15 cm. long including the rather open inflorescence: leaves several from each crown, mostly oblong, with 5–9 pinnae, on slender petioles: pinnae 7–15 mm. long, alternate or irregularly opposite, oblong, flabelliform or suborbicular, more or less deeply palmately parted into oblong obtuse or acutish lobes; stem-leaves short, with fewer pinnae (3–5) and short petioles (or subsessile); stipules ovate-oblong: flowers few–many on slender pedicels in an open cyme: calyx rotate, with flat pentagonal hypanthium with a marginal flange giving a sunken or inverted salverform effect (as in the base of the calyx of some species of *Physalis* in fruit); lobes ovate, acute, about 3 mm. long, fully twice as long

as the small linear-oblong bractlets: petals white, shorter than the lobes of the calyx, the small linear-lanceolate blade scarcely longer than the slender claw: stamens 5; the brown anthers subspherical, their cells opening lengthwise: pistils 3–5, sometimes all maturing: achenes large (2 mm. long), flattened, ovoid, with the inner edge nearly straight, noticeably longitudinally ridged on the surface.

This plant has the foliage of some of the sections of *Horkelia*, the numerical plan of certain species of *Ivesia*, while the calyx characters come nearest to *Comarella*. Unfortunately this cannot get into that genus since in it the petals are red and the pistils only two. On the whole the plant here described probably comes nearest to *Horkelia Baileyi* (Wats.) Rydb. The specific name chosen refers to the delightful fragrance emitted by the plant.

It does not seem possible to maintain these three genera in view of the increasing number of species that show characteristics that overlap the generic bounds. In fact, what character, except the open space between pistil-bearing receptacle and the margin of the hypanthial disk, separates any of them constantly from *Potentilla?* Agreeing in this one character and overlapping as to other characters, it is in the interest of simplicity to let *Horkelia* include them all.

No. 1708, Castle Ford, on the Salmon, in Idaho, is the type. It was found hanging in wet crevices on the vertical faces of basaltic cliffs, June 25, 1912.

POTENTILLA GLOMERATA **dichroa,** n. comb.—*Potentilla dichroa* Rydb. N. A. Fl. 22:319. 1908.

This is distinguished from the species only by the denser tomentum on the under side of the leaves and the grayer color of the plant as a whole.

Astragalus owyheensis, n. sp.—Spreading, prostrate, many-stemmed perennial, tufted at base, minutely and sparsely strigillose, the slender wiry stems, including the open racemes, 2–6 dm. long: stipules triangular, the lower about 3 mm. long and scarious, upward becoming smaller and green: leaves 6–10 cm. long, rather irregularly pinnate; the leaflets (5–13) remote, shorter than the internodes, linear: the very open axillary racemes exceeding the leaves: the slender pedicels 3–6 mm. long: calyx finely strigillose with intermingled black hairs, the subulate teeth about one-third as long: flowers 8–10 mm. long, white; standard 5 mm. wide, rather deeply emarginate, the edges strongly recurved, forming two crests at the edge near the middle of the blade: wings not emarginate, narrowly obovate, the edges incurved: keel shorter, with a broad

rounded incurved apex: pod oblong-linear, pubescent like the plant, shortly acute, 10–18 mm. long, straight or slightly curved, usually recurved but sometimes ascending, one-celled, the dorsal suture being but slightly intruded: seeds few (about 5).

Perhaps this finds its nearest relatives in *A. atratus* Wats. and *A. obscurus* Wats. No. 1887, collected July 2, 1912, above the "Hot Hole" of the East Bruneau, Owyhee Co., Idaho, is the type. It was quite inconspicuous because of its color and its habit of creeping among the short grasses of the sagebrush plains.

GERANIUM CAESPITOSUM **gracile,** n. comb.—*G. gracile* Engelm. in Gray Pl. Fendl. 27. 1849; *G. atropurpureum* Heller, Bull. Torr. Bot. Club **25**:195. 1898; *G. furcatum* Hanks, N. A. Fl. **25**:16. 1907.

Specimens of *G. caespitosum* when they show a tendency to become glandular pubescent on the pedicels have been considered as *G. gracile* (*G. atropurpureum*), and if this glandulosity extends to the stem they are *G. furcatum*. A series of specimens can be so arranged as to show all degrees of glandulosity to the complete lack of it. The proposed variety, therefore, rests primarily upon the slenderer and more erect stems, the narrower petals, and usually a trace of glandulosity. Where the glandulosity becomes marked throughout, it merges into *G. Parryi* (Engelm.) Heller.

It is somewhat singular that there should be any misunderstanding in regard to *Geranium caespitosum* James. Admitting that the original printing of the name did not publish the species, Dr. GRAY'S diagnosis in Pl. Fendl. 25 and Dr. TRELEASE'S in Bost. Soc. Nat. Hist. **4**:72 fixed the plant to which this name must apply.

Specimens answering to this description are not rare in the herbaria and are always non-glandular and with the pubescence of the stem (whether sparse or abundant) more or less retrose. The plant is always cespitose, growing in the form of a turf or mat from which short assurgent stems arise. The new characterization in the N. A. Fl. **25**:15 would seem to be without warrant, and at best that description presents merely one of the variants of *G. Fremontii* Torr.

Specimens wholly typical of *G. caespitosum* are BAKER 448, Colorado; BAKER, EARLE, and TRACY 407, Colorado; 1155 from Colorado, distrib. by the New York Bot. Gard. as one of the type nos. of *G. Cowenii* Rydb.; BUFFUM, Wyoming; NELSON 8591, Wyoming; METCALF 194, New Mexico; MACDOUGAL 118, Arizona. Besides *G. Cowenii*, *G. marginale* Rydb. must undoubtedly be referred to *G. caespitosum* as here understood.

GENTIANA AFFINIS **major,** n. var.—Leaves uniformly narrower: calyx lobes oblong-lanceolate, nearly equal and all approximately

equaling the tube: corolla broadly funnelform, larger, diameter at the top more than 2 cm.; the plaits purple, alternating with green bands extending downward from the lobes, the sinuses short.

This would be a good species if all degrees leading to the above characters were not present in a collection of *G. affinis*. Collected at Mountain City, Elko Co., Nevada, August 9, 1912, no. 2178.

Nemophila explicata, n. sp.—Branching from the base; the branches sometimes sparingly branched, 7–15 cm. long, spreading or weakly erect, glabrate, the scattering hairs short and refracted: leaves obovate or orbicular in outline, cuneately tapering into a margined petiole one-fourth to one-half as long as the blade, crenately 3–5-lobed, 10–20 mm. long, sparsely strigulose with more or less appressed hairs: pedicels 7–14 mm. long, at length more or less reflexed or even refracted: flowers small, not white; calyx appressed strigulose, in fruit 2 mm. or scarcely more long; its tube short; its lobes ovate, sparsely short ciliate on the margins, its appendages small, oblong, as long as the tube: corolla small, barely exceeding the calyx, tubular-campanulate, its oval lobesal most as long as the tube, the plicae or appendages wholly wanting: style short, divided at apex only: capsule 3–4 mm. long, more or less appressed cinereous-strigulose: seeds 4, large, 3 mm. long, irregular quadrants, slightly roughened, pale yellow with numerous small brownish dots or obscurely pitted; the membranous cellular caruncle caplike.

Secured at Jarbidge, in the canyon of the East Bruneau River, among shale-lava, growing with *N. breviflora* Gray. Only one other of the described species seems to be devoid of appendages in the corolla tube. No. 2229, July 7, 1912, is the type.

Phacelia foliosepala, n. sp.—Slender annual, 7–12 cm. high, hirsute-pubescent and glandular, trichotomously branched (candelabra-like) twice or thrice, the branches usually simple, floriferous to near their bases: leaves few, scattering, 1–1.5 cm. long, oblanceolate, obtuse, tapering below to a short margined petiole: inflorescence racemose, rather open in fruit (flowers unknown): pedicels about 2 mm. long: calyx lobes foliar, unequal, resembling the leaves, 10–15 mm. long, more than twice as long as

the capsule: capsule oval: seeds 12, irregularly ellipsoidal, beautifully alveolate, seal brown when mature.

Possibly this may best be referred to the section EUTOCA Gray, but even in this section there seems to be no species nearer to it than *P. linearis* (Pursh) Holz. That, however, is a very different plant in its mode of branching, in its different and glandless pubescence, and probably in all of its floral parts as it evidently is in its calyx. It is interesting that this little annual possessed (according to the field notes) a "strong vile odor, something fierce," reminding one of those perennials like GOODDING'S *P. foetida* that proclaim their identity while they are still a long way off.

The type is no. 2232, Gold Creek, Nevada, July 27, 1912; moist sunny flat.

Oreocarya cilio-hirsuta, n. sp.—Biennial or, apparently, sometimes perennial, from a slender taproot more or less branched at summit; the branches of the caudex or crown short and clothed with the inordinately crowded linear leaf-bases: stems several–many, very slender, somewhat angled, greenish but thinly hirsute and with an admixture of long white stiff ciliate-appearing hairs, 15–30 cm. long and floriferous in the axils for half their length: crown leaves very numerous, 2–4 cm. long, linear, the upper part more or less spatulate and not more than half as long as the slender petiolar portion; cauline shorter, mostly broadly linear; all with pubescence similar to that of the stems: the rather small axillary thyrsoid clusters 10–15, crowded above, more open below and usually surpassed by the foliar bracts: inflorescence moderately hirsute-hispid: calyx lobes linear-lanceolate, 6–8 mm. long in fruit: corolla tube barely as long as the calyx, its lobes suborbicular, half as long as the tube: nutlets ovate as to the body but narrowed and subacute at apex, bordered by a filiform wing-margin, sparsely but sharply muriculate on the back, even more minutely on the ventral side, not at all rugulose; scar linear, nearly as long as the nutlet, slightly enlarged at the base but not forked.

The type is no. 1799, from Minidoka, Idaho, June 23, 1912, where it was growing in the loose sagebrush soil. MACBRIDE'S no. 93 from New Plymouth, May 21, 1910, and his no. 875, from Sand Hollow, June 2, 1911, were distributed as *O. affinis* and *O. affinis perennis* respectively. Neither of these accord very closely with the species to which they were referred, and although not identical with the species here proposed, they will probably have to be considered a part of it rather than of *O. affinis*.

CASTILLEJA MINIATA Dougl.—Special effort was made to secure as full a series as possible in this genus in order to see something of the degree of variability within specific lines. No species shows how great this variability is better than *C. miniata*. Incidentally it may be remarked that the making of synonyms is not always due to the variability in the specimens representing a species, but quite as often to errors in the original descriptions which authors continue to copy and with which we constantly compare new material. Another source of error is found in the habit, more or less prevalent, of naming up material by comparison alone. *A* has a specimen slightly aberrant; *B* names his by comparison with *A*'s, and lets it pass though evidently somewhat different; *C*, having *B*'s plant, names his material accordingly, and so on. Look through any well filled species cover and see these facts illustrated.

In the original description of *C. miniata* the galea is said to exceed the corolla tube. On the assumption that this was so for the species (it probably was on the type sheet) some segregates have been made by various authors that had better not have been made. *C. miniata* material measured by this yardstick contains few (if any) specimens that are typical. Dr. RYDBERG, for example, in working all the material for his *Flora of Montana* had but one number (RYDBERG and BESSEY 4965, Wolf Creek, 1897). Unfortunately, too, other sheets of even this same number (4965) show only corollas in which the galea is shorter than the tube. The character is therefore more or less unreliable in this species, and hence probably in others.

Another character in *Castilleja* which is often misinterpreted is the root system. Collectors almost always pull the stems loose from the root or caudex. Being usually numerous in the clumps they are decumbent at base, and more or less rooted at the lower nodes. This often gives them the appearance of having been detached from a running rootstock when such was not the case.

Of course it is generally known that the color of the bracts varies, and this gives the plants a very different look even when the color of calyx and corolla remains (as it should) fairly constant.

These observations were induced by the necessity of distributing several of our numbers as *C. miniata* in spite of the fact that they refuse to accord fully

with the hypothetical type. For example, our nos. 2131 and 2132, growing together in "placer wash," agree in having a large intricately branched root, from the crown of which the stems spring. Both have corollas with the galea yellowish-green, scarcely as long as the tube, but our field notes read as follows: "2031, bracts most remarkably bright red; 2132, bracts a splendid golden yellow with orange tips." No one studying these two critically can fail to decide they are the same species, and can scarcely fail to refer them to *C. miniata*.

Castilleja Bennittii, n. sp.—Very short-lived perennial, sparsely hirsute throughout with a short dense cinereous subscabrous indument underneath: stems few, simple or often branched, 2–3 dm. high: leaves linear, entire or irregularly lobed, the lobes narrower than the blade: inflorescence dense, becoming more open and slender in age, old rose in color: bracts three-cleft, the lobes blunt, the middle the largest: calyx 15–20 mm. long, the subequal clefts only about 5 mm. deep, these divisions shallow-lobed, the short rounded lobes terminating the prominent ciliate calyx nerves: corolla slightly, sometimes scarcely, exserted, 15–22 mm. long; the galea about half as long as the tube, the short rounded teeth hardly differentiated in the strongly nerved saccate lower lip.

There seems to be no near relative to which to ally this species, unique in its color and floral parts. It was pronounced new in 1911 on the strength of specimens submitted by DORMAN BENNITT of Twin Falls. It is a pleasure to dedicate it to its discoverer, who accompanied the collectors on part of the 1912 trip and assiduously assisted in the field work. The type is no. 1714 secured on the sagebrush plains of Shoshone and Twin Falls, June 24, 1912.

CASTILLEJA RHEXIFOLIA **pubens,** n. var.—The branches of the caudex and the stem-bases scaly: stems numerous (usually several of them short and sterile), with a villous crisped pubescence quite to their bases: lower leaves also with a similar, though shorter pubescence.

No. 2023, on stony brush slopes, from Jarbidge, Nevada, July 11, 1912, is taken as the type.

Castilleja curticalix, n. sp.—Plants harsh to the touch, often decidedly so, in rather small clumps, from short-lived perennial roots: stems few–many, 2–4 dm. high, simple or nearly so, softly cinereous-hirsute near the base, becoming glabrate upward: leaves

numerous, scarcely smaller above, often rather closely ascending, scabrous on both sides, sometimes ciliate on the margins, linear to narrowly lanceolate, 2–6 cm. long, usually entire, but not rarely with one pair of widely divaricate lobes: bracts resembling the leaves: the moderately crowded inflorescence at length rather open, predominating color yellow or greenish-yellow, but often flushed with red: calyx 1.5 cm. long, scarcely exceeding the corolla tube, subequally cleft above and below, the primary divisions cleft at apex into long acute teeth: corolla 2–2.5 cm. long, galea 7–10 mm. long, the lower lip scarcely saccate, with very short teeth, the outer the longer.

Apparently the nearest allies of the proposed species are *C. fasciculata* A. Nels. and *C. lutescens* (Greenm.) Rydb. It differs from both in the very short calyx, also from the former in the harsh pubescence (in which it resembles *C. lutescens*), and from the latter in the narrower leaves. No. 2099 from Gold Creek, Nevada, July 24, 1912, is taken as the type. No. 2098 from the same locality and 1983 from Jarbidge, July 8, are both fairly representative. It occurs mostly on grassy slopes.

CASTILLEJA FASCICULATA **inverta,** n. var.—Much resembling the species, but pubescence merely a fine puberulence: calyx exceeding the corolla, more deeply cleft above than below, its lobes short-bifid: galea and lip subequal.

Practically all the perennial species formerly referred to *Orthocarpus* have been transferred to *Castilleja*, even when the corolla lips are subequal. This seems advisable, the more so in the present instance, because of its evident affinity with *C. fasciculata* A. Nels. In the subequal lips of the corolla, which is surpassed by the calyx, the proposed variety is strongly differentiated, and if subsequent collections show the characters given above to be constant it will become *C. inverta*.

Secured at Rattlesnake Springs, Idaho, on hard gravelly soil among the sagebrush, no. 1915, July 4, 1912.

Pentstemon rex, n. sp.—Having the pubescence, herbage, and aspect of *P. perpulcher* A. Nels., BOT. GAZ. **52**:273. 1911.—Corolla bright blue, about 3.5 cm. long, rather abruptly ampliate above the tube proper, wholly glabrous without and within as are also the anthers: sterile filament slightly dilated, glabrous or sparsely hispid-pubescent with short unequal hairs: anther cells dehiscent from the base upward for about three-fourths their length, leaving a closed saccate apical portion.

This could be referred to *P. perpulcher* were it not for the strong contrast between its rather small flowers and the large showy ones of this. Then the dehiscence character is unique in the *P. glaber* group. Some of the red-flowered species of *Pentstemon*, recently erected into a separate genus by Dr. GREENE, have anthers in which the upper portion of the cells remain closed and saccate, but none are known to the writers in the other sections of the genus. The SACCANTHERA section, of course, has anthers in which the base of the cell is the part that remains closed.

The following four numbers are all representative, but the first is named as the type: no. 1999, Jarbidge, Nevada, July 9, 1912; no. 977, MACBRIDE, Twilight Gulch, Owyhee Co., Idaho, June 23, 1910 (distributed as *P. speciosus* Dougl.); 1774, House Creek, Owyhee Co., Idaho, June 29, 1912; 2157, Bieroth's Ranch (McDonald Creek), Nevada, August 2, 1912.

PENTSTEMON PERPULCHER **pandus,** n. var.—Smaller than the species, the leaves more or less curved or arcuate: puberulence very dense, that of the stem extending to the rachis but not to the pedicels and calyx.

No. 1884, July 2, 1912, on the high plains, near the "Hot Hole" of the East Bruneau is the type.

Downingia brachyantha (Rydb.), n. comb.—*Bolelia brachyantha* Rydb., Mem. N.Y. Bot. Gard. **1**:458. 1900.

Downingia corymbosa (A. DC.), n. comb.—*Clintonia corymbosa* A. DC. Prodr. **7**:347. 1838.

Because of some splendid specimens secured of these species in the field work of 1912, our attention has been called to the fact that in accordance with the action of the Vienna Congress ("*nomina conservanda*") these species must be transferred.

Erigeron elkoensis, n. sp.—Plant low, subcinereous with a rather dense short more or less retrose pubescence throughout, with a short simple or sparingly branched caudex clothed with dead leaf-bases: stems few, simple, decumbent-ascending, monocephalous, leafy throughout or often naked-pedunculate above, about 4–10 cm. long: leaves numerous on the crowns, 2–4 cm. long including the petiole, oblong-spatulate, subacute, tapering to a narrowly winged petiole as long as or longer than the blade, inclined to be conduplicate; stem leaves similar, becoming smaller upward and linear: heads large, 20–25 mm. broad: bracts lance-linear, acute, unequal, one-nerved, in 2–3 series, the inner scarious-margined,

entire or fimbriate, granular-glandular, the outer green, hirsute as well as glandular: rays 15–20, conspicuously purple, rather broad, 3-toothed at apex: disk flowers yellow: achenes (young) pubescent.

In habit this suggests *E. leiomeris* Gray, but in other respects is very different. No. 2068, secured on open pebbly slopes, near Pole Creek in the Burnt Timber Mountains, Elko Co., Nevada, is the type.

ERIGERON POLIOSPERMUS **latus,** n. var.—Rougher pubescent than in the typical form, the crowns of the caudex clothed with dead leaf-bases: leaves unusually broad (3–4 mm.): heads large, very broad (the disk about 15 mm.) and the rays rather long and broad: involucre sparsely hispid, with the tips of the bracts granular-glandular, otherwise nearly or quite naked: rays purplish to white: achenes brown, glabrate.

This was a most striking plant on the black volcanic sands on which it was secured. In habit and aspect it suggested the *E. compositus* group rather than its real affinity, and led to its being tentatively designated as a species, *E. latus*. The technical characters, however, scarcely warrant such a disposition. Three Creek, Owyhee Co., Idaho, no. 1861, July 1, 1912.

ROCKY MOUNTAIN HERBARIUM
UNIVERSITY OF WYOMING, LARAMIE

SIR JOSEPH DALTON HOOKER

F. O. BOWER

[In a memorial oration delivered at the University of Glasgow, June 25, 1912, Professor BOWER spoke of Sir JOSEPH D. HOOKER as a traveler, a geographer, a geologist, a morphologist, an administrator, a scientific systematist, and a philosophical biologist. There is danger that HOOKER's great contributions to taxonomy will overshadow, for the biologists of a later generation, his important relation to the development of evolutionary theory. With the permission of Professor BOWER, therefore, that part of his oration dealing with HOOKER as a philosophical botanist is here reproduced.—EDITOR.]

I hope I have not wearied you with these brief sketches of four of the great systematic works of Sir JOSEPH HOOKER. I have gone somewhat more into detail than is quite justified in a public speech. But this has been done with a definite end in view. It was to show you how fully he was imbued with the old systematic methods; how he advanced, improved, and extended them, and was in his time their chief exponent. His father had held a similar position in the generation before him. But the elder HOOKER, true to his generation, treated his species as fixed and immutable. He did not generalize from them. His end was attained by their accurate recognition, delineation, description, and classification. The younger HOOKER, while in this work he was not a whit behind the best of his predecessors, saw further than they. He was not satisfied with the mere record of species as they were. He sought to penetrate the mystery of the origin of species. In fact, he was not merely a scientific systematist in the older sense. He was a philosophical biologist in the new and nascent sense of the middle period of the nineteenth century. He was an almost life-long friend of CHARLES DARWIN. He was the first confidant of his species theory, and, excepting WALLACE, its first whole-hearted adherent. But he was also DARWIN'S constant and welcome adviser and critic. Well indeed was it for the successful launch of evolutionary theory that old-fashioned systematists took it in hand. Both DARWIN and HOOKER had wide and detailed knowledge of species as the starting-point of their induction.

Before we trace the part which HOOKER himself played in the drama of evolutionary theory, it will be well to glance at his personal relations with DARWIN himself. It has been seen how he read the proof-sheets of the *Voyage of the Beagle* while still in his last year of medical study. But before he started for the Antarctic he was introduced to its author. It was in Trafalgar Square, and the interview was brief but cordial. On returning from the Antarctic, correspondence was opened in 1843. In January 1844 HOOKER received the memorable letter confiding to him the germ of the theory of descent. DARWIN wrote thus: "At last gleams of light have come, and I am almost convinced that species are not (it is like confessing a murder) immutable: I think I have found (here's presumption!) the simple way by which species become exquisitely adapted to various ends." This was probably the first communication by DARWIN of his species theory to any scientific colleague.

The correspondence thus happily initiated between DARWIN and HOOKER is preserved in the *Life and letters of Charles Darwin*, and in the two volumes of *Letters* subsequently published. They show, on the one hand, the rapid growth of a deep friendship between these two potent minds, which ended only beside the grave of DARWIN in Westminster Abbey. But what is more important is that these letters reveal, in a way that none of the published work of either could have done, the steps in the growth of the great generalization. We read of the doubts of one or the other; the gradual accumulation of material facts; the criticisms and amendments in face of new evidence; and the slow progress from tentative hypothesis to assured belief. We ourselves have grown up since the clash of opinion for and against the mutability of species died down. It is hard for us to understand the strength of the feelings aroused, the bitterness of the attack by the opponents of the theory, and the fortitude demanded from its adherents. It is best to obtain evidence on such matters at first hand, and this is what is supplied by the correspondence between DARWIN and HOOKER.

How complete the understanding between the friends soon became is shown by the provisions made by DARWIN for the publication of his manuscripts in case of sudden death. He wrote in August 1854 the definite direction "HOOKER by far the best man

to edit my species volume," and this notwithstanding that he writes to him as a "stern and awful judge and sceptic." But again, in a letter a few months later, he says to him "I forgot at the moment that you are the one living soul from whom I have constantly received sympathy." I have already said that HOOKER was not only DARWIN'S first confidant, but also the first to accept his theory of mutability of species. But even he did not fully assent to it till after its first publication. The latter point comes out clearly from the letters. In January 1859, six months after the reading of their joint communications to the Linnaean Society, DARWIN writes to WALLACE "You ask about LYELL'S frame of mind. I think he is somewhat staggered, but does not give in. . . . . I think he will end by being perverted. Dr. HOOKER has become almost as heterodox as you or I, and I look at HOOKER as by far the most capable judge in Europe." In September 1859 DARWIN writes to W. D. FOX "LYELL has read about half of the volume in clean sheets. . . . . He is wavering so much about the immutability of species that I expect he will come round. HOOKER has come round, and will publish his belief soon." In the following month, writing to HOOKER, DARWIN says: "I have spoken of you here as a convert made by me: but I know well how much larger the share has been of your own self-thought." A letter to WALLACE of November 1859 bears this postscript: "I think that I told you before that HOOKER is a complete convert. If I can convert HUXLEY I shall be content." And lastly, in a letter to W. B. CARPENTER, of the same month, DARWIN says: "As yet I know only one believer, but I look at him as of the greatest authority, viz. HOOKER." These quotations clearly show that, while LYELL wavered, and HUXLEY had not yet come in, HOOKER was a complete adherent in 1859 to the doctrine of the mutability of species. Excepting WALLACE, he was the first, in fact, of the great group that stood round DARWIN, as he was the last of them to survive.

The story of the joint communication of DARWIN and of WALLACE to the Linnaean Society "On the tendency of species to form varieties, and on the perpetuation of varieties and species by natural means of selection" will be fresh in the minds of you all, for the fiftieth anniversary of the event was lately celebrated

in London. It was Sir CHARLES LYELL and Sir JOSEPH HOOKER who jointly, and with the author's permission, communicated the two papers to the society, together with the evidence of the priority of DARWIN in the inquiry. Nothing could then have been more apposite than the personal history which Sir JOSEPH gave at the DARWIN-WALLACE celebration, held by the Linnaean Society in 1908. He then told, at first hand, the exact circumstances under which the joint papers were produced. Nor could the expressions used by the President when thanking Sir JOSEPH, and presenting to him the DARWIN-WALLACE Medal, have been improved. He said: "The incalculable benefit that your constant friendship, advice, and alliance were to Mr. DARWIN himself, is summed up in his own words, used in 1864: 'You have represented for many years the whole great public to me.'" The President then added: "Of all men living it is to you more than to any other that the great generalization of DARWIN and WALLACE owes its triumph."

Having thus sketched the intimate relations which subsisted between HOOKER and DARWIN, it remains to appraise his own positive contributions to philosophical biology. He himself, in his address as President of the British Association at Norwich in 1868, gives an insight into his early attitude in the inquiry into biological questions. "Having myself," he says, "been a student of moral philosophy in a northern university, I entered on my scientific career full of hopes that metaphysics would prove a useful mentor, if not a guide in science. I soon found, however, that it availed me nothing, and I long ago arrived at the conclusion so well put by AGASSIZ, when he says 'We trust that the time is not distant when it will be universally understood that the battle of the evidences will have to be fought on the field of physical science, and not on that of the metaphysical.'" This was the difficult lesson of the period when evolution was born. HOOKER learned the lesson early. He cleared his mental outlook from all preconceptions, and worked down to the bed-rock of objective fact. Thus he was free to use his vast and detailed knowledge in advancing, along the lines of induction alone, toward sound generalizations. These had their very close relation to questions of the mutability of species. The subject was approached by him through the study

of geographical distribution, in which, as we have seen, he had at an early age become the leading authority.

The fame of Sir JOSEPH HOOKER as a philosophical biologist rests upon a masterly series of essays and addresses. The chief of these were the introductory essay to the *Flora Tasmaniae*, dealing with the antarctic flora as a whole; the essay on the distribution of arctic plants, published in 1862; the discourse on insular floras in 1866; The Presidential address to the British Association at Norwich in 1868; his address at York, in 1881, on geographical distribution; and finally, the essay on the vegetation of India, published in 1904. None of these were mere inspirations of the moment. They were the outcome of arduous journeys to observe and collect, and subsequently of careful analysis of the specimens and of the facts. The dates of publication bear this out. The essay on the antarctic flora appeared about twenty years after the completion of the voyage. The essay on the vegetation of India was not published till more than half a century after HOOKER first set foot in India. It is upon such foundations that HOOKER'S reputation as a great constructive thinker is securely based.

The first-named of these essays will probably be estimated as the most notable of them all in the history of science. It was completed in November 1859, barely a year after the joint communications of DARWIN and WALLACE to the Linnaean Society, and before the *Origin of species* had appeared. It was to this essay that DARWIN referred when he wrote that "HOOKER has come round, and will publish his belief soon." But this publication of his belief was not merely an echo of assent to DARWIN'S own opinions. It was a reasoned statement, advanced upon the basis of his "own self-thought," and his own wide systematic and geographical experience. From these sources he drew for himself support for the "hypothesis that species are derivative and mutable." He points out how the natural history of Australia seemed specially suited to test such a theory, on account of the comparative uniformity of the physical features being accompanied by a great variety in its flora, and the peculiarity of both its fauna and flora as compared with other countries. After the test had been made, on the basis of the study of some 8,000 species, their characters, their spread,

and their relations to those of other lands, he concludes decisively in favor of mutability and a doctrine of progression.

How highly this essay was esteemed by his contemporaries is shown by the expressions of LYELL and of DARWIN. The former writes "I have just finished the reading of your splendid essay on the origin of species, as illustrated by your wide botanical experience, and think it goes far to raise the variety-making hypothesis to the rank of a theory, as accounting for the manner in which new species enter the world." DARWIN wrote "I have finished your essay. To my judgment it is by far the grandest and most interesting essay on subjects of the nature discussed I have ever read."

But besides its historical interest in relation to the species question, the essay contained what was, up to its time, the most scientific treatment of a large area from the point of view of the plant-geographer. He found that the antarctic, like the arctic flora, is very uniform round the globe. The same species in many cases occur on every island, though thousands of miles of ocean may intervene. Many of these species reappear on the mountains of Southern Chile, Australia, Tasmania, and New Zealand. The southern temperate floras, on the other hand, of South America, South Africa, Australia, and New Zealand, differ more among themselves than do the floras of Europe, Northern Asia, and North America. To explain these facts he suggested the probable former existence, during a warmer period than the present, of a center of creation of new species in the Southern Ocean, in the form of either a continent or an archipelago, from which the antarctic flora radiated. This hypothesis has since been held open to doubt. But the fact that it was suggested shows the broad view which he was prepared to take of the problem before him. His method was essentially that which is now styled "ecological." Many hold this to be a new phase of botanical inquiry, introduced by Professor WARMING in 1895. No one will deny the value of the increased precision which he then brought into such studies. But in point of fact it was ecology on the grand scale that Sir JOSEPH HOOKER practiced in the Antarctic in 1840. Moreover, it was pursued, not in regions of old civilization, but in lands where nature held her sway untouched by the hand of man.

This essay on the flora of the Antarctic was the prototype of

the great series. Sir JOSEPH examined the arctic flora from similar points of view. He explained the circumpolar uniformity which it shows, and the prevalence of Scandinavian types, together with the peculiarly limited nature of the flora of the southward peninsular of Greenland. He extended his inquiries to oceanic islands. He pointed out that the conditions which dictated circumpolar distribution are absent from them, but that other conditions exist in them which account for the strange features which their vegetation shows. He extended the application of such methods to the Himalaya and to Central Asia. He joined with ASA GRAY in like inquiries in North America. The latter had already given a scientific explanation of the surprising fact that the plants of the eastern states resemble more nearly those of China than do those of the Pacific slope. In resolving these and other problems, it was not only the vegetation itself that was studied. The changes of climate in geological time, and of the earth's crust as demonstrated by geologists, formed part of the basis on which he worked. For it is facts such as these which have determined the migration of floras. And migration, as well as mutability of species, entered into most of his speculations. The essays of this magnificent series are like pictures painted with a full brush. The boldness and mastery which they show sprang from long discipline and wide experience.

Finally, the chief results of the phytogeographical work of himself and of others were summed up in the great address on "Geographical distribution" at York. The Jubilee of the British Association was held there in 1881. It had been decided that each section should be presided over by a past President of the Association, and he had occupied that position at Norwich in 1868. Accordingly at York, HOOKER was appointed President of the Geographical Section, and he chose as the subject of his address "The geographical distribution of organic beings." To him it illustrated "the interdependence of those sciences which the geographer should study." It is not enough merely to observe the topography of organisms, but their hypsometrical distribution must also be noted. Further, the changes of area and of altitude in exposed land surfaces of which geology gives evidence, are

essential features in the problem, together with the changes of climate, such as have determined the advance and retrocession of glacial conditions. Having noted these factors, he continued thus: "With the establishment of the doctrine of orderly evolution of species under known laws, I close this list of those recognized principles of the science of geographical distribution, which must guide all who enter upon its pursuit. As HUMBOLDT was its founder, and FORBES its reformer, so we must regard DARWIN as its latest and greatest lawgiver." Now, after thirty years, may we not add to these words of his, that HOOKER was himself its greatest exponent?

You will have felt how tenuous is the line of limitation, if line indeed there be, between morphological reality and morphological abstraction; between the unit observed, and the summation of such units into a progression; between the static and the dynamic study of living things. It was this line that was crossed by DARWIN; and, as I have shown, HOOKER was the first of his friends to follow. To the general public he was perhaps the least known of the great triumvirate of Glasgow. The results he achieved do not touch everyday life so nearly as those of KELVIN or of LISTER. This is perhaps natural, for while he was the leading botanist of his time, he was, before all, a philosopher. In him we see the foremost student of the broader aspects of plant life at the time when evolutionary belief was nascent. His influence at that stirring period, though quiet, was far-reaching and deep. His work was both critical and constructive. His wide knowledge, his keen insight, his fearless judgment were invaluable in advancing that intellectual revolution which found its pivot in the mutability of species. The share he took in promoting it was second only to that of his life-long friend, CHARLES DARWIN.

UNIVERSITY OF GLASGOW

THE LICHENS OF MT. ROSE, NEVADA

ALBERT W. C. T. HERRE

Mt. Rose, with an altitude of 10,800 ft., is the highest peak in the region about Lake Tahoe, and lies about 15 miles southwest of Reno, Nev. A forest of *Pinus ponderosa* extends from the base of the peak at an approximate elevation of 6000 ft. to perhaps 8000 ft. The higher elevations on to the timber line, which is at an altitude of about 10,000 ft., are covered more or less by *Tsuga mertensiana*, *Libocedrus decurrens*, and *Pinus monticola*. During the Comstock boom this timber was greatly depleted, parts being deforested even up to the timber line. Along the water courses are scattered *Salix* sp., *Amelanchier* sp., and various smaller shrubs. Above 8000 ft. a large part of the mountain, in common with all the ranges about, is bare of trees and strewn with bowlders or plentifully sprinkled with dikes and outcrops of rock.

The remarkably original and valuable observations of Dr. J. E. CHURCH, of the University of Nevada, have furnished us with our knowledge of the climatology of Mt. Rose. For a number of years he has maintained on this isolated and well-nigh inaccessible peak a meteorological station unique in America. For a large part of the year snow lies upon the upper part of the peak, while at no time of the year is it entirely absent except where the winds keep the rock ledges swept bare. Snow may fall in quantity at any time of the year, though in late summer it nearly disappears, and when fresh-fallen lies but a short time. In the forested portion of the higher altitudes the snow forms great mounds which act as storage tanks, supplying water gradually to the lower levels. The summit temperatures are not excessively low, though of course cold weather prevails much of the time; -10° F. is the lowest recorded, but freezing weather occurs at any time of the year.

The most noticeable features of the lichen flora of the mountain are, so far as my observations extend, the utter absence of bark-dwelling species or those of dead or decorticated wood, and the equally conspicuous absence of earth lichens.

In part, at least, the absence of corticolous lichens is due directly to the winds of enormous velocity which are prevalent in this region. Gales of 50 miles an hour are frequent, while at times the inordinate velocity of 150 to 170 miles an hour is reached. As these winds sweep the mountain slopes, they carry sand or dust, sleet, and fine hard snow; the abrasive action of this flying material affects the bark of the conifers upon which it impinges in such a way that they appear as if freshly sandpapered. I was unable to find any indication of either lichens or mosses upon the bark of any tree or shrub examined.

The dearth of earth lichens may be in part explained by other causes, such as excessive dryness, the erosive action of floods caused by the rapid melting of snow when the Chinook winds blow in early spring, etc. But as yet I cannot understand the failure to find any trace of such genera as *Cladonia*, *Stereocaulon*, *Solorina*, *Cetraria*, and similar genera containing species characteristic of alpine situations. Perhaps prolonged search in early summer just after the disappearance of the greater part of the snow would reveal some of them.

The conditions noted above offer no hindrance to the growth of rock lichens. In the wooded slopes lichens occur on all rocks, but not abundantly, even where not shaded by the pines. But at 8000 ft. one comes suddenly into a region where lichens are both extraordinarily numerous and remarkably conspicuous. From here to the summit the dominant species is *Gyrophora reticulata*, which is excessively abundant; but the great bowlders strewing the mountain side and obstructing the trail are also spotted and blotched with huge, brilliant masses of *Acarospora chlorophana*, while *Caloplaca elegans* lends a gleam of fire to the somber landscape. The number of species occurring from here to the summit is very small, but this is amply compensated for by the number of individuals found in what one may term the *Gyrophora reticulata* formation. The species collected were as follows:

1. *Staurothele umbrina* (Ach.) Tuck.—Forming dark stains on rocks along the summit.

2. *Lecidea atrobrunnea* (Ram.) Schaer.—Abundant on all kinds of rocks at 8000 ft. and above; exceedingly variable, and perhaps

I have included more than one species, but as the more aberrant forms do not have fertile asci I cannot place them elsewhere. Varying in color from a clear saddle brown to black-brown. Much infested by a parasitic fungus which causes black, morbid, apothecia-like growths.

3. *Lecidea plana* Lahm.—Identification doubtful, but agrees in all essentials.

4. *Gyrophora rugifera* (Nyl.) Th. Fr.—Abundant on the south side of ledges at 10,800 ft. and for several hundred feet below; not found on the north side of the mountain. Growth luxuriant, but very rarely fertile.

5. *Gyrophora reticulata* (Schaer.) Th. Fr.—Excessively abundant from 8000 ft. upward. Occurring in all kinds of situations and forming the dominant lichen. Rather variable, but all forms may be referred to this species, whether typically foliose or reduced to a dense, uniform, crustaceous rock covering. According to the investigations of Dr. R. HEBER HOWE, who has recently examined the lichen types of the Linnaean Herbarium, *Lichen deustus* of LINNAEUS is really *G. reticulata*, which therefore becomes a synonym of *G. deustus* (Lin.) R. H. Howe.

6. *Acarospora chlorophana* (Wahlb.) Mass.

7. *Acarospora cervina* (Pers.) Koerber.

8. **Acarospora thermophila** Herre, n. sp.—Thallus somewhat orbiculate to effuse, areolate and fissured, of small lobulate squamules which are more or less stalked or stipitate beneath, the clustered stalks often branched, their height reaching 7 mm. Surface of squamules imbricate-lobate, the lobes very small, except marginally where they may be slightly expanded. Upper surface a pale yellow-brown or clay-brown; beneath black. No reactions visible.

Apothecia rare, small to medium, solitary or several grouped together, their surface more or less roughened and wrinkled, or sometimes fissured; an evident narrow thalline margin present; epithecium yellow-brown; hypothecium yellowish or very pale brownish; thecium colorless, turning to very deep blue with I; paraphyses simple, not septate, subcoherent, slender, their tips not enlarged; asci broadly clavate or top-shaped, measuring 24.8–

30.5 μ in breadth by 61–68 μ in length; spores colorless, exceedingly numerous, short ellipsoid to subglobose, 1–2 μ broad by 2–4.5 μ long.

Common on rocks everywhere in the desert about Reno, Nev., at an altitude of 4700 to 6000 ft.; not rare on Mt. Rose at 8000 ft. and above, and abundant in the Sierras along the Truckee River near the Nevada-California state line at an altitude of 6000 ft.

In a preceding paper (BOT. GAZ. **51**:286–297. 1911) this plant was mistakenly called by me *Acarospora thamnina*. It is certainly the most successful xerophyte of the Nevada desert, growing in the driest places, where it is exposed to the most intense light and heat. The apothecia are rarely developed, but the scales are commonly covered with a parasitic fungus so that they appear fertile, but their true condition is readily shown by careful sectioning.

9. **Acarospora thamnina** (Tuck.) Herre.—*Leconora thamnina* Tuck., Genera Lichenum, 120. 1872; *L. cervina* b. *thamnina* Tuck., Synopsis **1**:202. 1882.—Thallus of small, dense irregular clumps 8–15 or rarely 25 mm. or more in diameter, with domelike or irregularly rounded surface, or more or less flattened. On closer examination the surface is seen to be made up of a great number of small to minute, closely appressed, and highly irregular, plicate, or even imbricate, lobulate squamules; these are continued downward into stems which coalesce to form finally flattened, rootlike stipes, the whole clump with its basal stipe reaching a height of 10–15 mm. in well grown specimens. Color various shades of brown; often gray or bluish-gray pruinose; usually more or less blackened by a parasitic fungus; the under surface dead black. No reactions observable.

Apothecia rare, small or minute, 0.2–0.8 mm. in diameter, rarely more than one in squamule, immersed, their surface more or less roughened or gyrose; thalline margin entire, rather thick; much darker in color than the thallus; epithecium yellow; hypothecium pale; paraphyses simple, straight, their tips not enlarged, oleoguttate, 1–2.7 μ broad; asci cylindrical, 13–18 μ broad by 48–55 μ long; when treated with I the colorless thecium is first blue, then wine-red, and finally tawny; spores short ellipsoid to ellipsoid, 0.75–1.25 μ broad by 3.3–4.5 μ long.

A rare plant, known only from the cold high Sierras. Collected by BOLANDER at Mono Pass in 1867, and so far as I know not reported authentically by others. Occurring on earth deep in the crevices of rocks beside the observatory on the summit of Mt. Rose, associated with *Gyrophora rugifera*. For the determination of this singular *Acarospora* I am indebted to Dr. W. G. FARLOW, who kindly compared my material with that in the Tuckerman Herbarium.

10. *Lecanora rubina* (Vill.) Ach.

11. *Lecanora melanophthalma* (DC.) Jatta.

12. *Candelariella cerinella* (Flk.) A. Zahlbr.—On rocks at 10,800 ft. and also on the thallus of other lichens.

13. *Blastenia ferruginea* (Huds.) Arn.—On the thallus of other lichens and also on rocks at 10,800 ft.

14. *Caloplaca elegans* (Link) Th. Fr.—Common at all elevations from 8000 ft. to the summit.

15. *Caloplaca murorum* (Hoffm.) Th. Fr.—Not very abundant at 8000 ft.

16. *Xanthoria lychnea laciniosa* (Schaer.).—On the thallus of *Gyrophora rugifera* and in crevices of rocks at 10,800 ft.; not very plentiful.

17. *Physcia tribacia* (Ach.) Tuck.—A few small, sterile specimens were collected at 8000 ft. and at 10,800 ft.

EVERSON, WASH.

BRIEFER ARTICLES

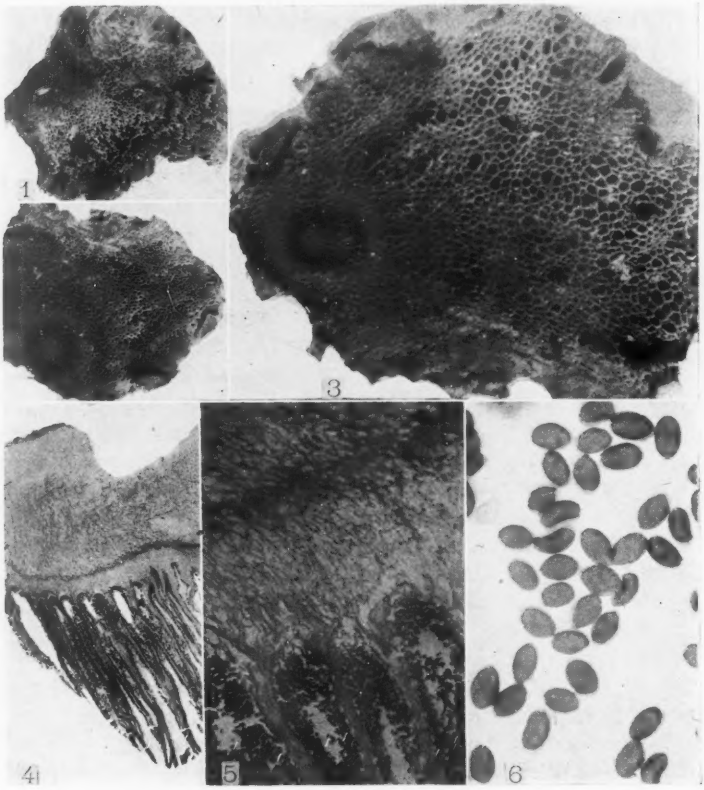
A NEW WOOD-DESTROYING FUNGUS

(WITH SIX FIGURES)

A very interesting polypore was sent to Professor ATKINSON at the botanical laboratory of Cornell University during the winter of 1912–13. The plant, collected by Dr. F. A. WOLF at the Alabama Polytechnic Institute, was found growing on some of the woodwork in the engineering building, where it was apparently causing considerable damage. A stairway and floor situated near water pipes were so badly rotted that it was necessary to replace them, and the wainscoting under the steps was entirely covered with a layer of mycelium, which was at first yellow and later dark brown. An examination showed that the mycelium was growing through the wood and also over the exposed surfaces, where it produced a soft papery layer of pale umbrinous color which could be easily separated from the substratum. In manner of growth and the appearance of the mycelium, the plant resembles *Merulius lacrymans*, but instead of the hymenophore being composed of the vermiform, anastomosing folds of that genus, a stratum of dark fuligineous pores was formed (figs. 1–3). The tubes were very fragile and friable when dry, the condition in which the fungus was found. A microscopic examination showed that the color of the tubes was almost entirely due to the very numerous dark brown spores which filled the pores and were often massed on the surrounding mycelium. The trama of the pores and the subiculum on which they were formed were composed of pale umbrinous hyphae (figs. 4, 5).

The wood on which the fungus was growing was in advanced stages of decay, of a dark brown color and checked into small cubes. Much of it could be crumbled between the fingers, and when sections were cut the spring wood separated from the summer wood. A part of the wood was bald cypress (*Taxodium distichum*) and a part long leaf pine (*Pinus palustris*). Strange to say, in the cypress the late or summer wood, which is more resinous, was more badly decayed than the spring wood, which in some places remained quite firm. The reverse was true in the pine; the spring wood in some instances was reduced almost to a powder, while the summer wood remained intact. All attempts to germinate the spores or to get a culture from the mycelium in the wood failed, so that no work with pure cultures, to find the action of the fungus on the wood or to determine with certainty that it was responsible for the decay present, was possible.

This plant seems to occupy a position in the Polyporeae similar to that of *Merulius lacrymans* and related species in the Meruliae and to *Coniophora* among the Thelephoraceae. It has the same dark dusty



FIGS. 1–6.—*Poria atrosporia:* figs. 1, 2, portions of fruiting surface, nat. size; fig. 3, same, ×2; fig. 4, photomicrograph of section through pores, ×10; fig. 5, same, ×76; fig. 6, photomicrograph of spores.

spore mass and the light colored mycelium forming thin sheets over the substratum. The spores of *Coniophora cerebella* and *Merulius lacrymans* are slightly different in color, being more brown than fuligineous, and those of *Coniophora cerebella* larger than the spores of this species, but they are of the same shape (fig. 6).

Search through the literature of described species revealed no plant of like character. It is therefore described as a new species, and provisionally placed in the genus *Poria*, although it is recognized that the plants of this genus are a heterogeneous group which sooner or later will be separated into several genera or distributed among the genera of pileate forms with which they correspond in texture and other characters. The specific name *atrosporia* is given because of the abundance of dark spores. A technical description is as follows:

Poria atrosporia, n. sp.—Mycelium within the substratum or in a superficial layer of soft cottony or thin papery consistency; color pale umbrinous: sporophore resupinate, broadly effused, easily separable: margin sterile, pale umbrinous: hymenophore porose, not stratose, very fragile and friable when dry; pores 1–5 mm. deep, dissepiments thin, mouths irregular to subrotund, 1–5 to a mm.: trama pale umbrinous, but pores deep fuligineous because of the abundance of dark spores; spores oval, dark brown, 4–5.5×8–10 μ; cystidia none. Habitat, structural timber of coniferous wood.

Mycelio substratum penetrante vel stratum superficium byssinum vel papyraceum formante; sporophora resupinata, late effusa, a matrice separabilis; margine sterili, umbrino-pallido; poris non stratosis, siccatis fragilis et friabilis, 1–5 mm. longis; parietibus tenuibus; ore irregulari vel subcirculari, 1–5 quoque mm.: trama umbrina-pallida sed poris fuligineis ob copiosos umbrinos; sporis ovatis 4–5.5×8–10 μ; cystidiis nullis. Hab. ad ligna fabricata coniferarum.—ADELINE AMES, *Cornell University, Ithaca, N.Y.*

A SAFETY RAZOR MODIFIED FOR CUTTING HAND-SECTIONS

(WITH ONE FIGURE)

Since the advent of the many styles of "safety razors," biologists have looked with covetous eye upon their keen and cheap blades, seemingly unadapted to any purpose except that intended by the manufacturer. Microtomists have produced several devices to utilize these keen edges and at the same time hold the blades solidly so as to avoid trembling, but, so far as I am aware, none of these razors has been used for hand-sectioning, or, if the blades have been used, the handles have been of no assistance.

Some time ago, needing section razors for the use of large classes, I looked over the various kinds of safety razors for sale in shops and found among them one known as the "Durham-Duplex," which, by slight modification, has become very well adapted to the purposes for which

students have need of a section cutter. This razor has two advantages over most safety razors, so far as our present purposes are concerned. In the first place, it is much like an old-style razor in general shape, the blade, however, being removable and protected by a nickel-plated brass guard. In the second place, the blades are thicker, longer, and stiffer than those provided with most safety razors.

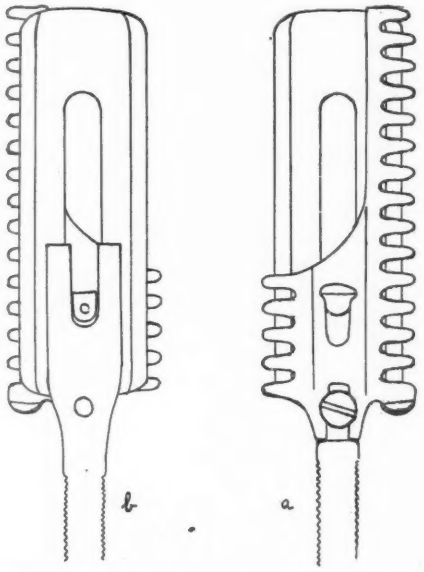


FIG. 1.—Modified safety razor: explained in text

The accompanying drawings (fig. 1) will show at a glance the changes that have been made upon the "Durham-Demonstrator." As shown by *a*, the protecting shield has been cut away so as to leave a portion of the blade exposed for use. The other drawing (*b*), showing the other side of the razor, illustrates the cutting off of the brass supporting handle, thus leaving the blade free beneath. A screw fitted into the handle at the base of the blade is at once the means of holding the latter rigid, as well as of permitting its easy removal for cleaning or changing the cutting edge, the slot filed into the base of the guard making of this a very simple operation.

In practice this razor has proved very successful with large classes, providing an abundance of sharp edges as well as saving the time of an assistant on whom the work of honing would otherwise fall.—J. P. GIVLER, *Southwestern College, Winfield, Kansas.*

ON STEMONITIS NIGRESCENS AND RELATED FORMS

That MACBRIDE, in his *North American slime-moulds*, retains *Stemonitis nigrescens* Rex as a distinct and well marked species, while the LISTERS, in their *Monograph of the Mycetozoa*, refer it unhesitatingly

and with only the briefest comment to *S. fusca*, seems to warrant some further elucidation. Judging by the type specimen only, a portion of which was sent to me some years ago by the late Dr. REX, one would be justified in according to his species at least varietal rank. The strikingly dark color, the stiff, upright habit of the sporangia, not curved or drooping even at the edges of the clusters, and their small size (stalk less than 1 mm., total height 4.5 mm. or less) are features which appear to render this form recognizable at sight. Moreover, many gatherings made during the past ten years in as widely separated localities as New England and Colorado show that this dark, dwarf form is fairly common in the United States. It should be noted also that with the distinct external features noted above certain microscopic features are usually associated, such as a more or less imperfect development of the surface net, the meshes of which show spinelike processes, and reticulated spores of a smoky-brown color.

A number of gatherings made in Colorado, however, throw light on the variable character of *S. nigrescens*. Seven such gatherings are before me. They all agree in the short-stalked, upright, dwarf habit, and in the reticulated spores. But the color of the clusters of sporangia varies markedly from dull ferruginous to almost black; the surface net in one of the specimens is as perfectly developed and as free from spinous processes as in any typical specimen of *S. fusca;* while the spores vary in color from pale to dark smoky-brown, the former showing a very faint and delicate reticulation which is much more pronounced in the case of the darker-spored specimens. I cannot but conclude that these are all forms of one and the same species, and that they should be regarded as a dwarf variety of *Stemonitis fusca* Roth.

This opinion is strengthened by the examination of a specimen collected at Pagosa Springs, Colorado, in August 1911. It shows the same dense clusters of stiff, upright, dark smoky-brown sporangia, short-stalked, and measuring less than 4 mm. in height. The small-meshed surface net shows a few small spines. The spores, 8.9 μ in diameter, are rather dark in color, but instead of being reticulated they are closely and minutely spinulose. In my opinion this is a dwarf form of *Stemonitis herbatica* Peck, and bears the same relationship precisely to that species as do the dwarf forms commented on above to *S. fusca*. I conclude, therefore, that the LISTERS were correct in merging *S. nigrescens* Rex with *S. fusca* Roth, but that the former constitutes a well marked variety, though ill-defined by the designation *nigrescens*.—W. C. STURGIS, *Colorado Springs, Colorado.*

CURRENT LITERATURE

BOOK REVIEWS

Physiological plant anatomy

The appearance of a fourth edition of HABERLANDT'S well known work,[1] almost exactly 25 years after the first edition was published, is an indication of the importance of the book and the service it has rendered to the physiological aspect of plant anatomy. The previous edition, reviewed in this journal,[2] has been completely revised, and the changes, although limited in extent, serve to incorporate the results of more recent investigation. The number of pages has been increased from 616 to 650, and the illustrations from 264 to 291.

Among the additions are sections entitled "Einrichtungen für besondere mechanische Leistungen," which include the discussion of various hairs and hooks functioning as supports of climbing plants; and "Speichergewebe für Atmungsstoffe" and "Speichergewebe für ökologische Zwecke," dealing with certain aspects of the storage tissues of plants, but presenting little new data.

The most important changes appear in the twelfth chapter, entitled "Die Sinnesorgane," which has been entirely rewritten, with the inclusion of much new material. Foremost among the new data are the results of the author's studies on the structure for light perception in leaves. They include the various lens cells or ocelli, as well as various cells below smooth outer surfaces. Several papers presenting these data have already been noted in these pages.[3] Both in this chapter and elsewhere in the volume the author maintains his well known teleological interpretation of the date in spite of the opposite trend of modern investigation. Fortunately this does not detract from the importance of his experiments or the accuracy of his data.—GEO. D. FULLER.

MINOR NOTICES

Key to trees.—The authors[4] of a *Key to New England trees* have again given us a convenient and reliable pocket manual pertaining to our native

[1] HABERLANDT, G., Physiologische Pflanzenanatomie. Vierte, Neubearbeitete, und vermehrte Auflage. Imp. 8vo. xviii+650. *figs. 291.* Leipzig: Wilhelm Engelmann. 1909. *M* 19.

[2] BOT. GAZ. **38**:146–148. 1904.

[3] COLLINS, J. FRANKLIN, and PRESTON, HOWARD W., Illustrated key to the wild and commonly cultivated trees of the northeastern United States and adjacent Canada. Small 8vo. pp. vii+184. *figs. 279.* New York: Henry Holt & Co. 1912. $1.35 in cloth, $2.50 in leather.

[4] BOT. GAZ. **42**:399. 1906, and BOT. GAZ. **48**:472–474. 1909.

trees and those common in cultivation in the northeastern United States and adjacent Canada. The book is free from unnecessary technical terms and descriptive details which are essential to a comprehensive flora, so that the volume can be used easily and intelligently by the layman as well as profitably by the scientifically trained individual. Identification of a given tree is made by a simple key, based on leaf characters, leading directly to the species, which is illustrated by an outline drawing of a typical leaf associated usually with a reproduced photograph in halftone of the bark. Each tree is given its scientific name, as well as the common name by which it is known. The drawings are all made in actual proportions, the natural size being shown graphically by a line-scale accompanying each figure. We need more such books to encourage and popularize careful field observation.—J. M. GREENMAN.

Officinal plants and drugs.—MITLACHER[5] has brought together in convenient compilation the plants recognized in all of the approved pharmacopoeias, 22 in number. The nomenclature is that of the Vienna Congress, and the sequence is that of WETTSTEIN'S *Handbuch*. The data given are as follows: geographical distribution and culture of medicinal plants, the vegetation form, the drugs obtained, those drugs regarded as especially strong and those recognized as "officinal" in different countries, etc. It is interesting to note the distribution of these 638 officinal plants, representing 125 families. Of the cryptogams, only 23 such plants are used (Phaeophyceae 2, Rhodophyceae 7, Fungi 7, Pteridophytes 7), representing 16 families; while the gymnosperms add only 21 conifers. The 594 officinal plants among angiosperms, representing 107 families, are distributed as follows: Archichlamydeae 323, Sympetalae 197, and Monocotyledons 74.—J. M. C.

Illinois Academy of Science.—The volume of transactions of the fifth annual meeting (February 1912) of the Illinois Academy of Science has just appeared. A symposium on conservation includes "Conservation of our forests," by HENRY C. COWLES, and "Conservation ideals in the improvement of plants," by H. J. WEBBER. In addition to these papers, the following of botanical interest were presented: "Notes on the forests of Ogle County, Ill.," by W. L. EIKENBERRY; "Competition and general relationships among the subterranean organs of marsh plants," by EARL E. SHERFF; "The range of evaporation and soil moisture in the oak-hickory forest association of Illinois," by WADE MCNUTT and GEO. D. FULLER; and "Germination and growth of the cottonwood upon the sand dunes of Lake Michigan, near Chicago," by GEO. D. FULLER.—J. M. C.

Volvox.—An extended discussion of *Volvox*, based upon living and fixed material mounted whole in glycerin jelly, is presented in a pamphlet by JANET.[6]

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[5] MITLACHER, WILHELM, Die offizinellen Pflanzen und Drogen. pp. viii+13. Wien: Carle Fromme. 1912. *M* 6.25.

[6] JANET, CHARLES, Le *Volvox*. 8vo. pp. 151. *figs.* 15. Limoges: Ducourtieux et Goût. 1912.

The colony is compared with the blastula stage of animal embryology, and has a pore like the blastopore. The antheridium develops in the blastula fashion with a "phialopore," as does also the new colony, whether formed asexually or from the egg. The figures are very diagrammatic, but interesting and probably accurate. No nuclear detail is attempted. The most striking feature of the paper is the terminology. Every structure has a technical name, even when ordinary literary French would serve as well.—CHARLES J. CHAMBERLAIN.

NOTES FOR STUDENTS

Inheritance in maize.—COLLINS[7] has made some interesting observations on the progeny of an all-white ear of maize that appeared suddenly in a field planted with a variety known as Gorham yellow dent. Since the character with which he was dealing develops in the endosperm and usually shows complete dominance in crosses, this variation is out of the ordinary. The author classes it as a case of mutative reversal of dominance. To the reviewer such a view respecting the phenomenon seems unwise. In the descendants of the seeds of this ear, yellow was dominant to lack of yellow in varying degrees; it only remains then to explain the non-development of yellow in the original aberrant ear. It has been generally accepted that dominance or lack of dominance is only another way of describing the somatic appearance of a heterozygote. It has nothing to do with segregation and is valuable simply as an indication of zygotic composition. The true classification of any individual can be determined only by breeding from it, for there are characters so variable in their dominance that the appearance of the heterozygote may be similar to either homozygote (*AA* or *aa*). In spite of its variability, however, dominance does not just happen. It has its causes. An individual *AA* may be crossed with various kinds of *aa* individuals and the degree of dominance be different in each cross, but these various manifestations are due to internal differences between the *aa* organisms. On the other hand, external conditions may affect the manifestation of a character either when in a heterozygous or when in a homozygous condition. One may assume, therefore, that dominance is not a phenomenon of great variability when both external and internal conditions of development are identical. For these reasons, the reviewer has a suspicion that COLLINS' mutative reversal of dominance was nothing but suppressed development due to some abnormal environmental condition, possibly the accidental presence of some particular metallic salt in the spot of soil in which the plant grew. The reviewer has observed somewhat similar phenomena, but has never thought his own ignorance of their exact cause a sufficient excuse for an attack on well established theories.

Seeds from COLLINS' "albinistic" ear were planted and the progeny investigated. His results show clearly that he was dealing with the behavior of two

[7] COLLINS, G. N., Heredity of a maize variation. Bur. Pl. Ind. Bull. 272. pp. 23. *pl. 1. fig. 1.* 1913.

factors for yellow endosperm, Y_1 and Y_2, of which one is much more effective in producing the yellow pigment than the other. Such an assumption he regards as "violent," it being just as violent as have been the assumptions of all Mendelian experimentalists who have made mathematical interpretations of breeding facts. The author is also greatly disturbed over the question of whether or not the segregation ratios that he obtained fit the theory of error. It seems to the reviewer, however, that considering the possibility of experimental error in work with maize, he is to be congratulated on having done some very careful work to have them fit "theory" as well as they do.

Notwithstanding the fact that the results obtained agree well with the assumption of two yellow factors that are given above, with only a few minor variations of classification due to the difficulty of distinguishing light yellows from white, the author concludes "that while the segregation is usually numerically exact, it is by no means complete; that is, the dominant character is not completely absent from individuals of the recessive class." "This," he says, "is shown not only by the presence of a faint yellow color in most of the seeds, but also by the fact that apparently pure white seeds from an ear in which the classes were well marked may produce seed with a fully developed yellow color when self-pollinated." Consequently he favors the idea of gametic impurity in the sense that extracted dominants and recessives may transmit traces of the alternative character.

Again this conclusion seems opposed to the facts submitted. If one has a set of light yellow and white seeds in an apparent ratio of 3:1, he makes his classification as best he may by somatic appearance. He then grows the whole series and finds out *what the true classification of the parents was.* This the reviewer has done on similar material, with the result that the ratio of the mother seeds *proved* to be 3:1; this the author either has not done or has not reported. If then the *white ears* obtained do not again breed true, one might have the right to assume gametic contamination; but the author reports no such evidence. As a matter of fact, extracted recessives and extracted dominants do appear to throw the alternative character on rare occasions, but the phenomenon is so rare that one may better assume that a germinal rearrangement (mutation) has occurred. Of course in any species some variations are more likely to occur than others, which may be taken as evidence of a kind of latency. But this is only the kind of latency that is analogous to the tendency of a chlorine atom to split off from a complex benzene derivative, rather than one of the more conservative radicals such as methyl. It is evidence that certain rearrangements in a particular germ plasm are more likely to occur than others.—E. M. East.

Studies of Nicotiana hybrids.—In two papers, appearing almost simultaneously, Goodspeed[8] has reported the results of his investigations on

[8] Goodspeed, T. H., Quantitative studies of inheritance in *Nicotiana* hybrids. Univ. Calif. Publ. **5**: no. 2. pp. 87–168. *pls. 29–34.* 1912; *ibid.* no. 3. pp. 169–188. 1913.

possible correlations between seed characters and plant characters, and on the inheritance of certain quantitative character complexes in crosses between various *Nicotiana* species and varieties.

In that part of the contribution concerned with somatic correlations the author deals with a cross between the varieties *virginica* and *macrophylla* of the species *Nicotiana tabacum*. F_1 seeds were divided arbitrarily into the classes light, medium, and heavy. The light and medium seeds germinated more quickly than the heavy seeds, and plants resulting from the former matured more quickly than those from the latter. It does not appear, however, that the general belief that heavy seed gives more vigorous plants than light seed is incorrect. Moreover, the total germination of heavy seed was higher than that of the other two classes.

The author continually speaks of the dominance of one plant over another, a mediaeval mode of expression that makes it impossible to draw any conclusions from his observations on his F_1 generation. Likewise he finds that the heavy seed gave, in F_2, 39 per cent of "dominants" (resembling *macrophylla*), 52 per cent of intermediates, and 9 per cent of "recessives" (resembling *virginica*); while the light seed gave 18 per cent dominants, 49 per cent of intermediates, and 33 per cent of recessives. With such a method of describing results it is not surprising that he invents a theory for their interpretation that will no doubt be very interesting to cytologists, for in it he assumes that the "tube nucleus" of the pollen grain unites with the fusion "endosperm" nucleus of the embryo sac. He assumes that there are two "determiners," one functioning to produce *virginica* characters and the other *macrophylla* characters. The generative nucleus, he says, may bear either, and the "tube nucleus" may bear either. The same alternatives are assumed for the egg nucleus and the fusion "endosperm" nucleus. Then, simply by having a *macrophylla* generative nucleus unite with a *macrophylla* egg nucleus, and a *macrophylla* "tube nucleus" unite with a *macrophylla* fusion nucleus, he gets a heavy seed having *macrophylla* characters. *Quod erat demonstrandum*. Charitably granting that the words "tube nucleus" were slips of the pen, there is no excuse for founding a theory that the two male nuclei carry different "determiners" upon unsupported data of this character.

In the second part of his work, the author has studied the degree of dominance and the variation in size of corolla diameter in the parents and F_1 generation of crosses between varieties of *Nicotiana acuminata*. The corolla breadth of the F_1 generation was found to be the arithmetical mean of the two parents. The fluctuation in corolla breadth, both in individual plants and in the population as a whole, was greater in F_1 than in the parents. These conclusions, at least as to the degree of variability of the F_1 generation, are at variance with the results of several careful investigators (the reviewer can count twelve such offhand), but it is impossible to criticize GOODSPEED'S data, for he does not give them in the form of frequency distributions. He simply reports maximum and minimum measurements, which may or may not mean anything.

He does indeed give two plates of frequency polygons, but his distributions are for number of flowers measured on particular dates, with no statement as to their size, and for relative frequency of flowers of certain sizes, with no data on the actual number of flowers measured or the number of plants upon which they were borne. Apparently the parents upon which data were taken were too few to warrant such sweeping conclusions.

In the second paper, also, one gathers that the F_2 generation there reported on is more variable than the F_1 generation; but no data are recorded. This paper purports only to be a note, however, and one may expect some data of greater consequence when the really large amount of work that the writer has done is reported in full.—E. M. EAST.

Knot disease of citrus trees.—HEDGES and TENNY[9] give a complete account of a knot disease of citrus trees that had been briefly described in a preliminary account by Miss HEDGES.[10] The disease has been found on lime trees in Jamaica and in one instance in Florida. It manifests itself by woody knots or swellings which appear on the branches and trunks of the diseased trees. The knots are usually round or somewhat elongated in the direction of the axis of the branch which bears them. They attain a diameter of 2–3 inches, and by their growth usually girdle the branch upon which they are seated, this causing the death of all the parts of the branch above the knot. Groups of fascicled branches, forming witches-brooms, often grow out from the knots, but these branches also are short-lived. The knots consist mostly of woody tissue, at first covered by bark which soon dies and crumbles away. All the tissues of the knots, as well as the tissues of the branches near the knots, are found to be infected with the brown mycelium of a fungus which was described by Miss HEDGES as *Sphaeropsis tumefaciens*. The mycelium of this parasite has been observed to spread to a distance of 45 cm., and it seems probable that it can spread to greater distances. Secondary knots are produced by the mycelium which spreads through the branches. The growth of the fungus on a large number of media, its characteristics, and numerous infection experiments are described at length by the authors.—H. HASSELBRING.

The cause of leaf asymmetry.—BOSHART, working in GOEBEL's laboratory, reports the results of certain observations and experiments on asymmetry and anisophylly.[11] He concludes that the size of any given leaf part is determined by the area it occupies in the vegetative point. Further development

[9] HEDGES, F., and TENNY, L. S., A knot of citrus trees caused by *Sphaeropsis tumefaciens*. Bur. Pl. Ind. Bull. 247. pp. 9–74. *pls. 10. figs. 8.* 1912.

[10] HEDGES, FLORENCE, *Sphaeropsis tumefaciens*, nov. sp., the cause of the lime and orange knot. Phytopath. **1**:63–65. *pl. 1.* 1911.

[11] BOSHART, K., Beiträge zur Kenntnis der Blattasymmetrie und Exotrophie. Flora **103**:91–124. 1911.

depends on nutrition, a poor food supply causing but slight enlargement of the part, whereas a good food supply causes considerable enlargement. The vegetative point, on the other hand, is unrelated to nutrition, so far as its symmetry is concerned. Contrary to most previous investigators, BOSHART finds no evidence that gravity or light influences leaf symmetry. It is believed rather that both anisophylly and leaf asymmetry are merely an expression of the symmetry of the plant as a whole. For example, anisophylly, and in most instances asymmetry also, is associated with dorsiventrality, radial shoots being characterized commonly by isophylly and symmetry. It seems very doubtful if this radical view, giving little or no place to the operation of external factors, will displace the many experimental contributions of past years. Even in this contribution it is admitted that good nutrition can result in the development of the vegetative point of a dorsiventral shoot into a radial shoot. It would seem, then, according to BOSHART, that external factors determine what sort of a shoot develops, but that the type of leaf is tied up inexorably with a particular kind of shoot.—HENRY C. COWLES.

Photometric leaves and shoots.—WIESNER in continuing his already very extensive studies upon the light relations of plants returns to the consideration of the orientation of leaves in response to the direction of incident light. Fixed and variable positions[12] are distinguished and examples of the latter, which he regards as the more perfect response, are multiplied, the legumes furnishing the major portion. More exact studies are made of leaves only apparently related to light and termed pseudophotometric,[13] in contrast to those actually orienting themselves in response to incident light, and emphasis is laid upon the part played by epinasty and geotropism acting before and simultaneously with phototropism. Most photometric leaves are found to be pseudophotometric in the earlier stages of their development.

Relations similar to those existing in leaves are shown to obtain for shoots.[14] All shoots with photometric leaves are shown to be themselves photometric, but the category also includes the shoots of such conifers as *Abies* and *Tsuga*, with leaves showing very slight responses to light. The effect of light of different intensities is to be seen in the shoots of *Taxus baccata*, being perpendicular, that is showing euphotometry, while with more intense light they become panphotometric. Some interesting cases of the photometry of anisophyllous shoots are also discussed.—GEO. D. FULLER.

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[12] WIESNER, J. v., Über fixe und variable Lichtlage der Blätter. Ber. Deutsch. Bot. Gesells. **29**:304–307. 1911.

[13] WIESNER, J. v., Über aphotometrische, photometrische, und pseudophotometrische Blätter. Ber. Deutsch. Bot. Gesells. **29**:355–361. 1911.

[14] WIESNER, J. v., Über die Photometrie von Laubsprossen und Laubsprossystemen. Flora **105**:127–143. 1913.

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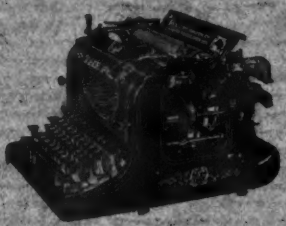

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